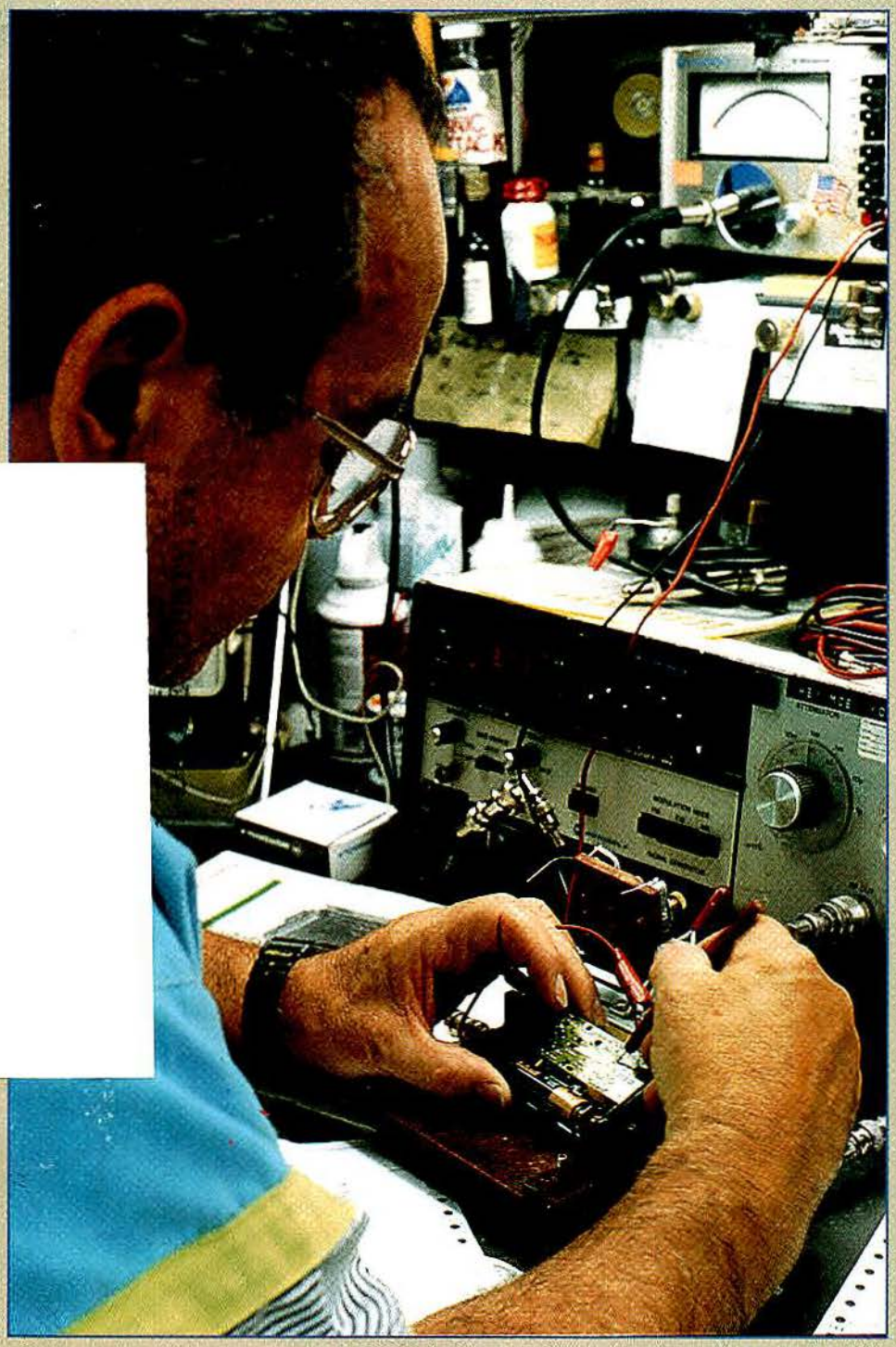
May 1996

Mobile Radio Technology™

Technical information for paging, SMR and private wireless networks.



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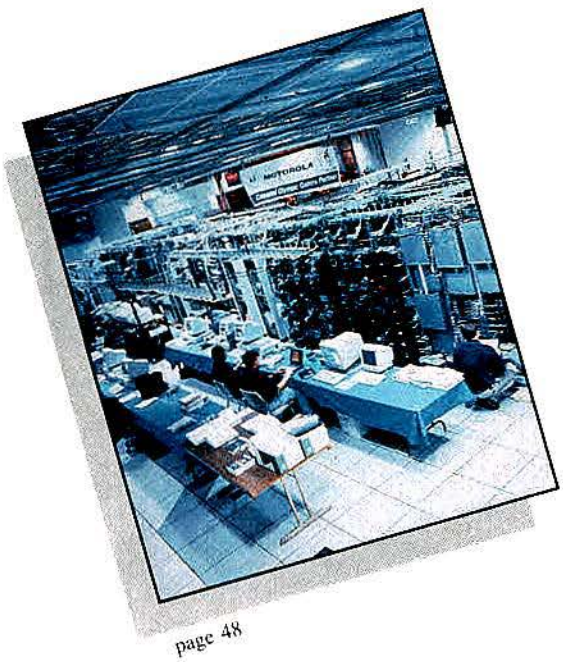
Contents

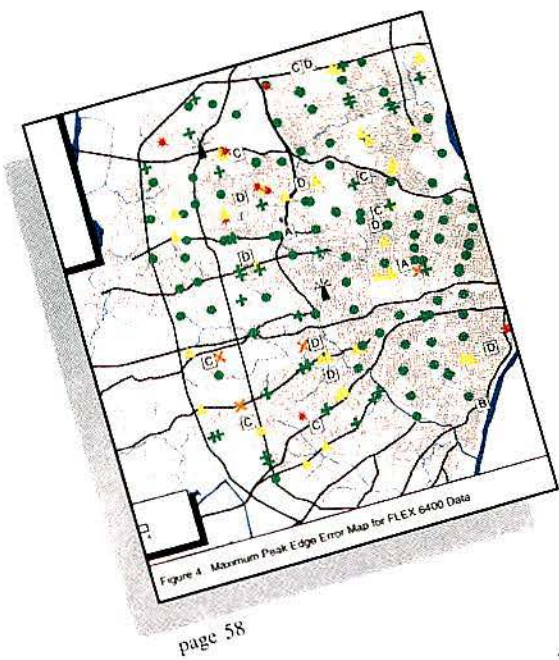
Mobile Radio Technology™

Technical information for paging, SMR and private wireless networks

Volume 14, Issue 5



page 48



page 58

features

On the cover: Angelo Talignani, a pager service technician at Regional Communications, Paramus, NJ, troubleshoots a pager in the company's shielded room.

departments

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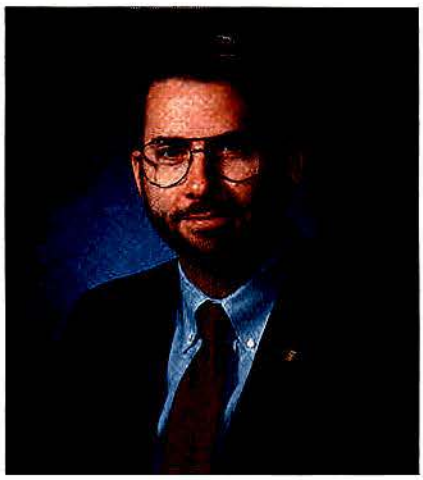
See the Phoenix SC20-500 at the '96 IWCE Show. Booth 1441

International Wireless Communications Expo... suggestions, anyone?



A lot of effort goes into producing the International Wireless Communications Expo (IWCE). As a press delegate at the 1983–1995 shows, we appreciated the results without being fully aware of the work required to obtain them. When Intertec Publishing ceased publishing *Communications* magazine, the opportunity to serve as IWCE's conference program chairman came our way, as well as a new perspective on the conference and the exhibition.

Many people helped us to define the conference sessions and to find speakers, including our friends at our former competitor, Argus Business, which is now part of our company.

In particular, we'd like to thank those who organized their own sessions, including people at trade associations that cosponsored some of this year's sessions. Among them are Kimberly A. Sescoe of the Industrial Telecommunications Association (ITA), Alan R. Shark of the American Mobile Telecommunications Association (AMTA) and Nancy Palleschi of the Personal Communications Industry Association (PCIA).

Harry E. Young of MTA-EMCI organized the panel on number portability, Joe Gallelli of Midland Systems organized the APCO 25 Update panel and Ramona Vassar Isbell of *Cellular & Mobile International* magazine organized the wireless local loop panel.

Elsa Saavedra, an editor with Intertec Publishing and chairman of the IWCE Latin American Conference Program, organized the sessions on Latin American Regulation, International Agreements and Emerging Technologies.

We also thank Robert H. Schwaninger Jr. of the Brown and Schwaninger law firm for taking a leading role in the session planning and production. Schwaninger is our regulatory columnist and consultant, and we relied a great deal on his help in our first time to handle the programs.

Carrying out the session logistics fell to Kathleen Crigler, IWCE conference coordinator, and Ingrid Lawing, IWCE production manager, handled the printed materials. We thank them for responding so well to the ever-changing session lineup.

Thanks also go to everyone who accepted speaking engagements. Your willingness to express your views and to offer information to others helps everyone in our industry learn how to make their businesses more successful.

Did we leave anyone out? It wasn't on purpose. Many people contributed their efforts to the conference program, and everyone's help is appreciated.

Now, about complaints. We've always heard complaints about IWCE. It's just that, before this year, they weren't directed at us! We always thought that there was a lot that was right about IWCE. As with everything, though, there always is room for improvement. Also, we learn more from criticism than from congratulations. So feel free to tell us what can be done better, and we'll see what can be done about using your suggestions at next year's show.

* * *

Spectrum refarming

New technical, regulatory and operating requirements for the private mobile radio services in frequency bands below 800MHz continue to draw attention. Although the FCC has taken initial steps toward splitting channels to make more frequencies available, the government plan has not satisfied everyone. Assignments of high-powered stations on the 450MHz offset channels, for example, are part of the government plan. Unfortunately, such assignments could interfere with telemetry and medical devices, affecting the safety of life and property.

The old "offsets" are now "refarmed" channels, so a resolution of this problem is essential before many benefits of refarming can be realized.

Bringing modern propagation analysis to bear on new channel assignments could boost the number of new stations that could share refarmed spectrum with less interference. One of the organizations that has been leading the way in providing information about spectrum refarming is the Industrial Telecommunications Association (ITA). With its own seminars and with sessions conducted in cooperation with IWCE and ENTELEC, the Association is helping dealers and private radio system users take advantage of the initial refarming changes. Watch for announcements about ITA's spectrum refarming sessions.

—Don Bishop

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Calendar

May

14–17—PCIA Spring Government Conference, sponsored by the Personal Communications Industry Association, Washington Hilton, Washington, DC. Contact: Nancy Palleschi, 202-467-4770.

29–31—Canadian Wireless, sponsored by the Canadian Wireless Telecommunications Association, Metro Toronto Convention Center, Toronto. Contact: 613-233-4888.

June

16–20—UTC National Conference & Exhibition, sponsored by UTC, The Telecommunications Association, Marriott Hotel and Bartle Hall Convention and Civic Center, Kansas City, MO. Contact: 202-872-0030.

23–27—Supercomm, sponsored by USTA and TIA, Dallas Convention Center, Dallas. Contact: 800-278-7372.

July

11–13—Communications Expo/Show of the Americas, Miami, FL. Contact: 305-229-9992.

14–17—Forestry-Conservation Communications Association annual conference, Howard Johnson Plaza Hotel, Madison, WI. Contact: Tom Tuttle, 608-246-7998.

August

11–15—International Association of Public-Safety Communications Officials (APCO) National Conference, San Antonio, TX. Contact: 800-949-2726.

September

19–21—Personal Communications Showcase, sponsored by the Personal Communications Industry Association, Moscone Convention Center, San Francisco. Contact: 800-326-8638.

October

30–Nov. 1—WirelessWorld Conference and Exposition, sponsored by *Cellular Business* and *Mobile Radio Technology* magazines, Orange County Convention/Civic Center, Orlando, FL. Contact: Susan Link, 913-967-1969.

November

22—Radio Club of America, Communications Symposium, 87th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Ron Formella, 201-652-6811.

18–19—AMTEX, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, Intercontinental Hotel, Miami. Contact: 202-331-7773.

1997

April

22–24—International Wireless Communications Expo, co-sponsored by *Mobile Radio Technology*, Las Vegas Sands Convention Center, Las Vegas. Contact: 800-828-0420.

May

5–7—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Hyatt Regency at Civic Plaza, Phoenix, AZ. Contact: Wendy Rochelle, 908-562-3870; Fax 908-981-1769.

June

16–20—UTC National Conference & Exhibition, sponsored by UTC, The Telecommunications Association, Oregon Convention Center and Red Lion Lloyd, Holiday Inn & Travelodge Hotel, Portland, OR. Contact: 202-872-0030.

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Test equipment loading effects

By Harold Kinley, C.E.T.

Back to basics! Yes, sometimes it is important to take the time to digress to the basics that we were taught in technical school. Maybe some us missed class that day, or spring fever had a grip on our thoughts, or a number of other diversions might have captured our attention! Anyway, for whatever reason, some of the basic points sometimes seem so far away and very cloudy!

Have you ever been led on a wild goose chase by misleading readings from your test instruments? Practically all of us who have worked in this business for any length of time have been led astray from time to time by misleading or misinterpreted instrument readings. Let's look at some of the loading effects of test instruments and the underlying causes.

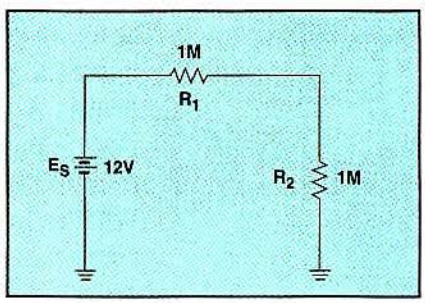

Figure 1. A simple dc circuit.

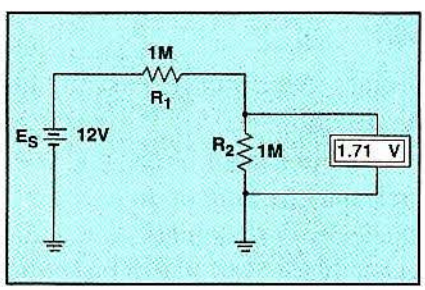

Figure 2. The voltmeter here simulates a multimeter with a sensitivity of 20,000 ohms/volt and set to the 10V range. On this range the meter has a shunting effect of 200,000Ω.

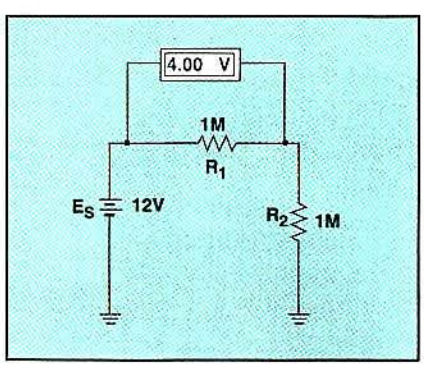

Figure 3. Here the multimeter has a dc sensitivity of 20,000 ohms/volt and is switched to the 50V range. Thus, it exhibits a shunt resistance of 1M to the circuit under test.

The multimeter

All multimeters are not created equal. Generally speaking, you get what you pay for in test equipment. You can save money up front but pay for it in time and frustration down the road. Let's compare some of the old analog multimeters and see what those sensitivity specifications really mean.

▶ *The VOM* — The old VOM (volt-ohm-milliammeter) has long been an essential piece of test equipment. Sensitivity of the old VOM multimeters was specified as so many ohms-per-volt (Ω/V). Let's examine the meaning of this in terms of measurements on a practical circuit.

The circuit shown in Figure 1 top, left is a simple dc circuit. Because the two series-connected resistors are both of equal resistance (1M), the 12V supply voltage should divide equally between the two resistors, producing a voltage drop of 6V across each resistor. So, we pull out our old trusty multimeter with a sensitivity specification of 20,000 ohms/volt to measure the voltage drop across the resistor R_2. Because the expected voltage reading is 6V, the multimeter scale is switched to the 10V range. (Actually, the old professor at technical school said to start with the highest voltage range and work downward—does anyone do that?)

So, with the multimeter switched to the 10V dc scale, the probes are touched across resistor R_2. What? The voltage reading is only 1.71V. (See Figure 2 on page 8.) Obviously, the reading indicates a malfunction in the circuit. Suspecting the supply voltage to be low, we place the multimeter probes across the supply voltage source. The voltage here reads the full 12V, as it should. The measurements taken thus far would tend to indicate that resistor R_1 has increased in value. (Resistors do it all the time!)

Because the voltage reading across R_2 was 1.71V, the reading across R_1 should be 12 *minus* 1.71, or 10.29V. (You do remember what the professor said about Kirchoff's law, don't you?) So, expecting a reading of 10.29V across R_1, the multimeter is switched up to the 50V scale, and the probes are connected across R_1. (See Figure 3 on page 8.) What? Only 4V? How can that be? According to what the professor said about Kirchoff's law, the sum of the voltage drops across the circuit should equal the supply voltage. But 4 *plus* 1.71

(continued on page 70)

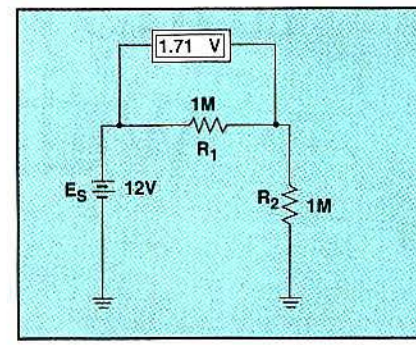

Figure 4. Multimeter across R_1 has a dc sensitivity of 20,000 ohms/volt and is switched to the 10V range. The shunt impedance is 200,000Ω.

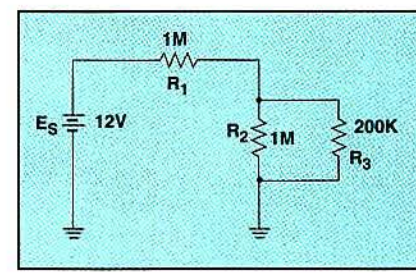

Figure 5. The multimeter has been replaced by a 200K resistor (R_3) to represent the shunt impedance of the meter on the 10V scale.

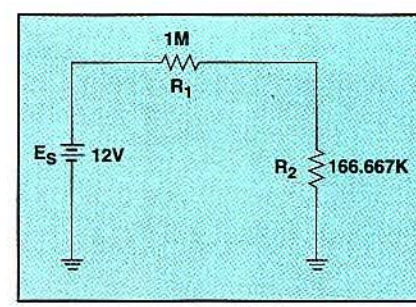

Figure 6. The circuit of Figure 5 has been reduced to this, with resistor R_2 representing the combined parallel impedance of the resistor and the multimeter input impedance.

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is a member of the Radio Club of America. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, which is available for direct purchase. Write to 204 Tanglewylde Drive, Spartanburg, SC 29301.

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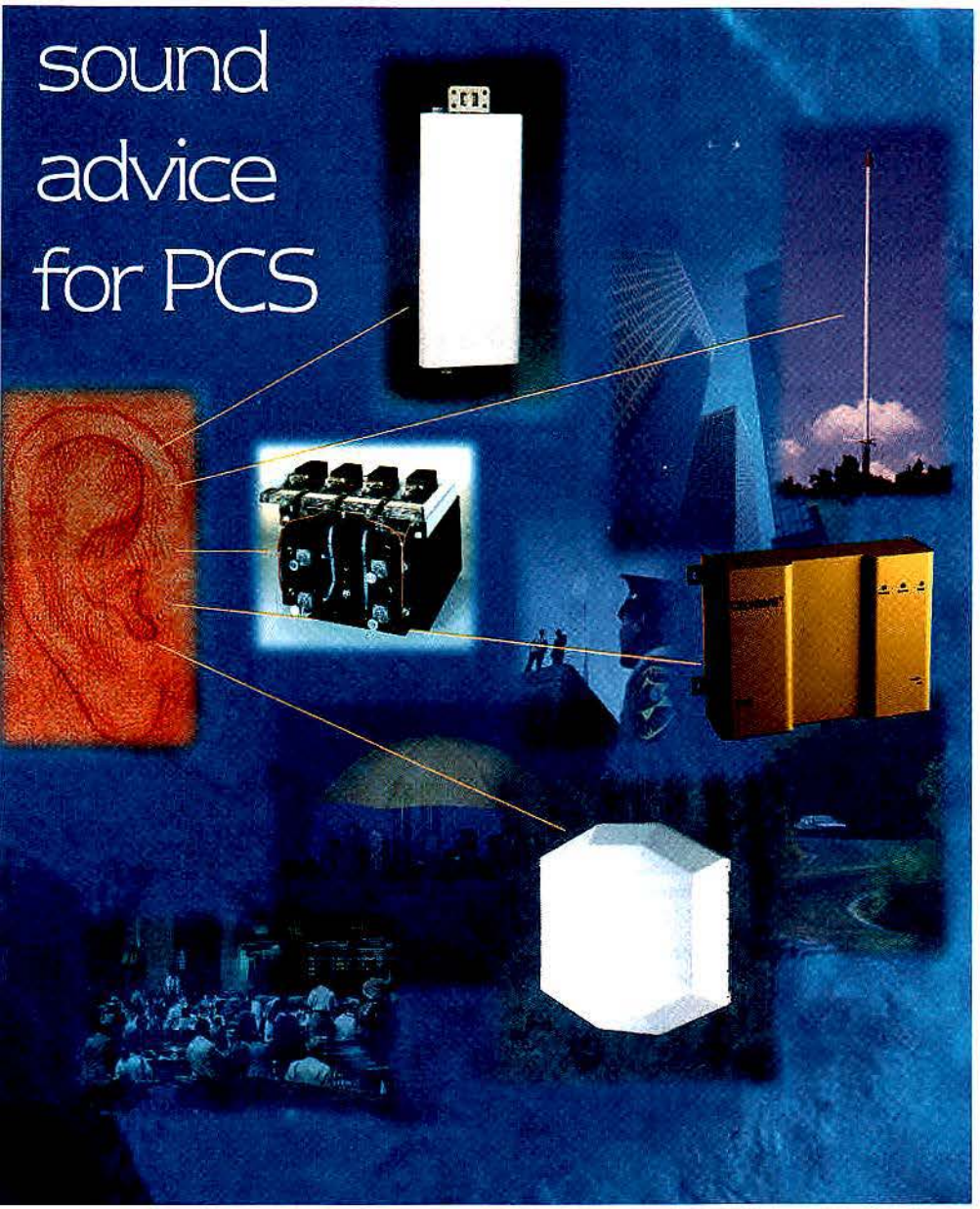

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Directive antennas offer improvements for cell sites

In the beginning, service providers placed their cell sites as high as they could, and added high-gain, omnidirectional antennas and blasted out as much power as they could to reach as far and as wide as possible.

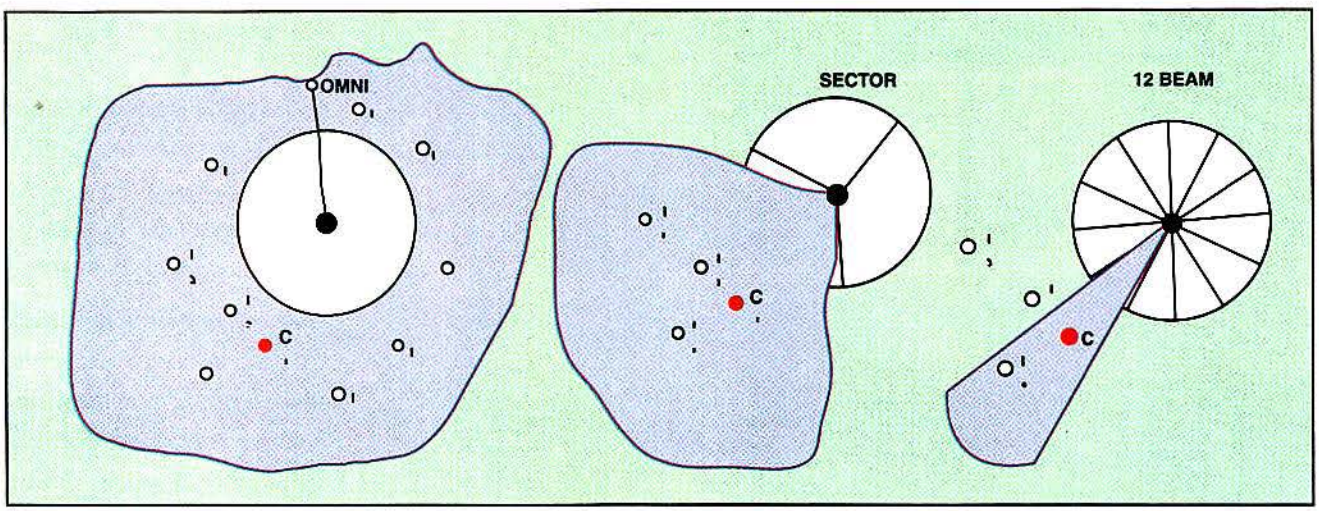

Figure 1. Omni antenna hears all interferers, 120° sector hears 1/3 of the interferers, and 30° sector hears only 1/12 of the interferers.

By Douglas O. Reudink, Ph.D., and Michael J. Kavanagh

Cellular providers are faced with the vexing problem of boosting capacity in their systems, which in turn increases interference at a time when call quality is an increasingly important issue. Metawave has attacked these problems by equipping cell sites with highly directive antennas that "track" desired mobiles and block out undesired ones. The result can be 50% better coverage, markedly better call quality, double battery life, and double system capacity.

Creation of cellular

In the beginning, service providers went to the mountaintop, placed their cell sites as high as they could, and added high-gain, omnidirectional antennas and blasted out as much power as they could to reach as far and wide as possible to serve their fledgling flock. Since there were lots of channels and not many customers, frequency re-use was hardly a consideration, and co-channel interference was not an issue. But, the deluge of customers, although a blessing for the marketing and sales departments, brought the curse of implementation for the engineers. The engineers had studied the BSTJ Bible (remember the old Bell System Technical Journal) well, however, and knew exactly what to do.

Mythical 7-cell re-use never happened

With six potential interferers around a cell site, odds are at least one is going to be strong enough to cause trouble often enough to be annoying and occasionally downright disrupting. Long before this happened, operators, as taught by their BSTJ-trained engineers, switched over to sectors. With sectors, the coverage pie is divided into three 120°-wide pieces. By doing this, at most, two co-channel interferers are visible, compared to six before. Besides, the interferers are a little farther away so that, on average, the interference power they create is somewhat lower. Now, the theory says that co-channel interference should be a rare event. An example of this is when a customer is at the edge of a cell and is shaded from the cell site a little bit, and at the same time a co-channel mobile a few cells away is in a similar situation. So over there is an interfering mobile at the edge of its cell trying to get a signal back to its cell, but spews energy across the adjacent cells and causes interference back at the home cell. Again, the theory says the propagation laws are such that the interference will always be too weak to cause much of a problem. However, everyone knows Murphy's laws are stronger than physical laws, and Murphy plays a mean game of statistics. So it seems that whenever the mobile in our cell drops into a little

Reudink is president and chief technical officer, and Kavanagh is product manager for Metawave Communications, Redmond, WA.

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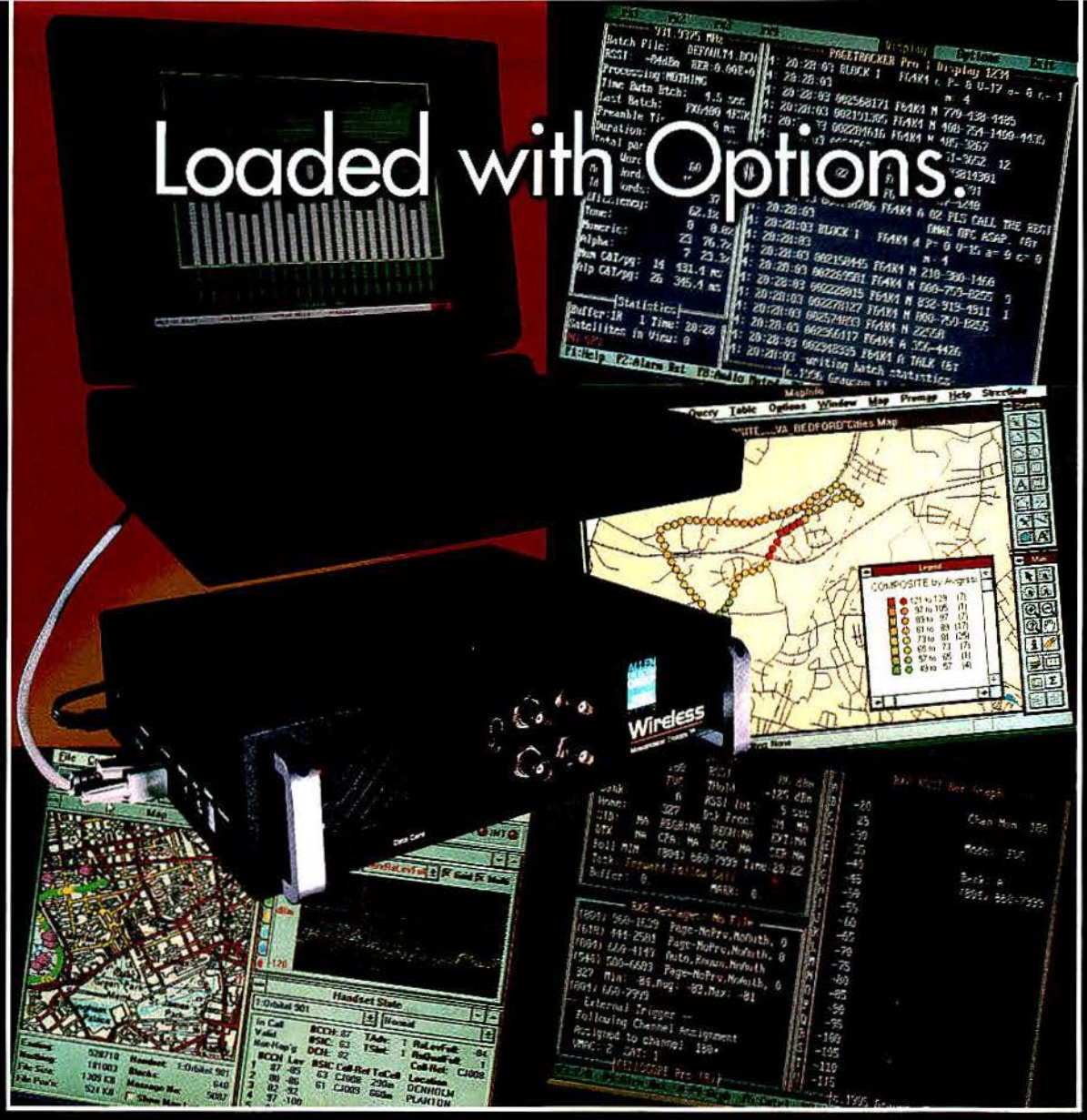

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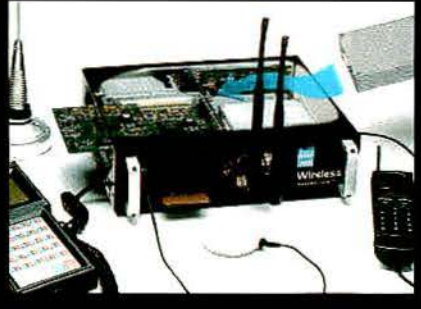

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propagation shadow, the interferer pops up into the clear causing havoc. Still, sectorization has helped a lot, because the directive antenna blocks out the interference from behind quite well, and from the sides fairly well.

Playing statistics with Murphy

The logical question is, if three sectors are better than omni, why not use six, 12, or 24 sectors and be even better? The theory says yes, it should work, but to be convincing, real-life propagation measurements were called for to find out what other secrets Murphy had lurking out there. Our company has performed extensive field tests at several locations in urban, suburban and rural areas to quantify the actual "what if" situation of 12 or 24 antenna beams being available at a cell site. The results showed that 12 beams provided a remarkable improvement in interference reduction close to the theoretical 6dB (i.e.: the average interference is reduced by 75%). (See Figure 1 on page 10.) With these test results in hand, Metawave settled on a 12-beam solution. Even though 24 beams provided more improvement than 12 beams, the added cost and complexity was not cost-effective. As we consider implementation in the next section, this will become clearer.

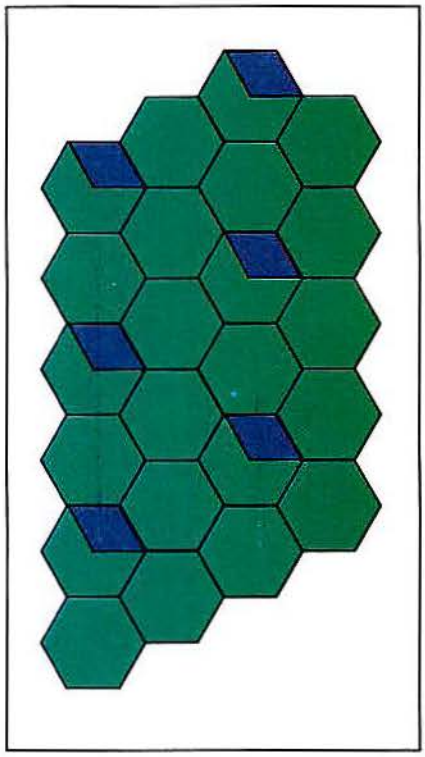

Figure 2. N = 4 reuse with a tri-sectored system.

More sectors alone will not help capacity

We can prove experimentally that a 12-sector system significantly reduces interference; however, sectorization alone actually *reduces* capacity. For example, an omni cell and a tri-sectorized cell each have a total of 57 channels, yet any one sector has only 19. Thus, for 1% blocking, the sector cell carries 11.2 erlangs* of traffic per sector, or a total of 33.6 erlangs, where the omni cell, having the benefit of a larger trunk group, can carry 44.2 erlangs for the same blocking probability. Carrying this example to a 12-sector system leaves on average slightly less than five channels per sector, which carries a pitiful 1.3 erlangs at 1% blocking. Of course, if the reuse cells can be brought closer together, capacity can be increased. A seldom-used reuse of four (N = 4) six-sector systems still has smaller

*An "erlang" is the equivalent to 1 voice circuit in use at all times.

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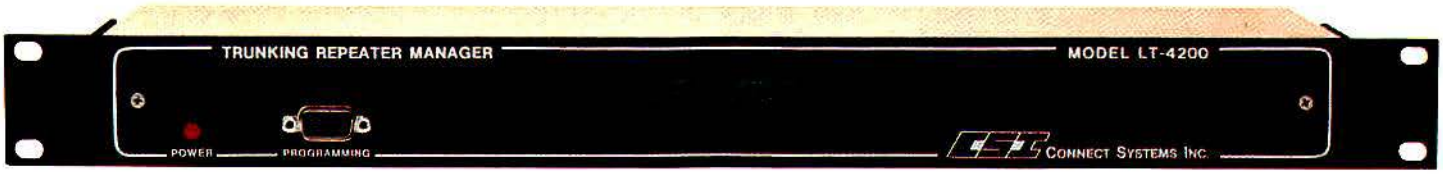

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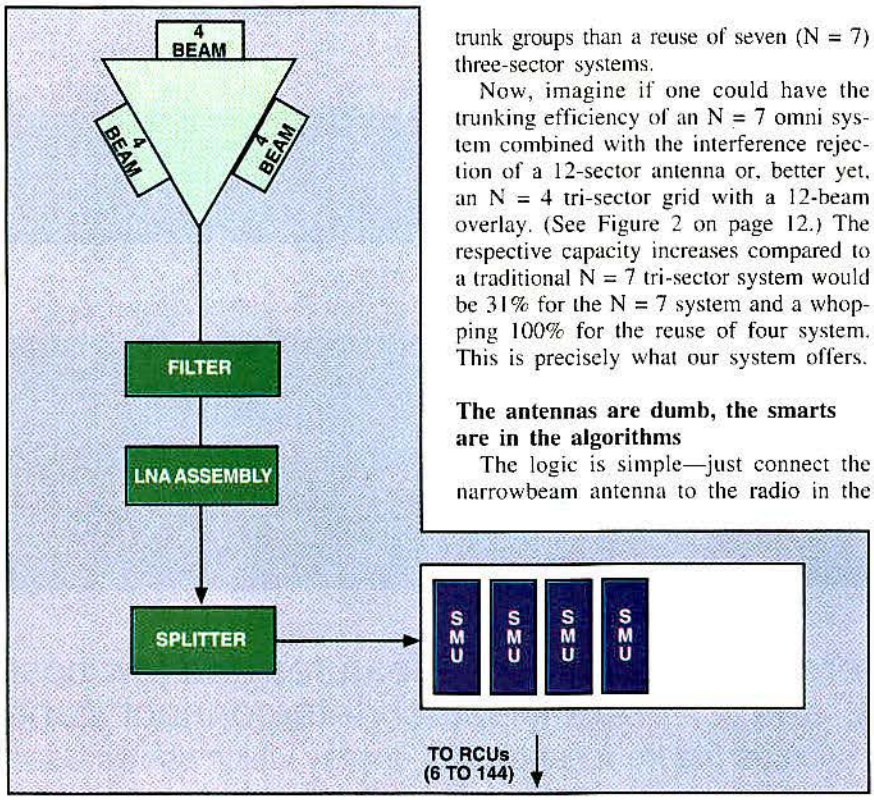

Figure 3. A 12-antenna setup for a receive-only system.

trunk groups than a reuse of seven (N = 7) three-sector systems.

Now, imagine if one could have the trunking efficiency of an N = 7 omni system combined with the interference rejection of a 12-sector antenna or, better yet, an N = 4 tri-sector grid with a 12-beam overlay. (See Figure 2 on page 12.) The respective capacity increases compared to a traditional N = 7 tri-sector system would be 31% for the N = 7 system and a whopping 100% for the reuse of four system. This is precisely what our system offers.

The antennas are dumb, the smarts are in the algorithms

The logic is simple—just connect the narrowbeam antenna to the radio in the cell site that *best* serves each mobile. The best signal may not necessarily mean the *strongest* signal because it could be corrupted by interference. Also, there is a need to address the question of the diversity port on the radio, and what about the transmitter? The answers to these and a host of other questions lie in algorithms based on extensive field measurements, propagation models, and self-learning. At the same time, it is extremely advantageous to be transparent to the existing hardware and software operating the cell site. Our solution provides 12 antenna beams with an active switch matrix as an overlay unit that replaces the sector antennas. For transmission, the current Class C amplifiers or linear amplifiers are replaced with a set of 12 amplifiers, one for each beam. For starters, there is a significant benefit available just from a receive-only system (See Figure 3 at the left.)

Receive-only system benefits portables

Cellular systems were designed for 3W mobile transmitters mounted on a ground plane (car roof). Among the many operating conditions, this determined the spacing between cell sites. Now along comes the three-fifths (0.6W) portable

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used *inside* the car, not outside. This often leaves coverage gaps between cell sites because there is not sufficient energy to reach back to the old cell site or forward to the new one. In rural areas it is not worth the cost of adding another cell site just to stop a few dropped calls; however, high-gain directive antennas can receive a ten times weaker signal compared to an omni antenna and roughly a four times weaker signal compared to a sector antenna. The greater sensitivity easily fills in the coverage gaps. Because the cell transmitter always has much more power than a portable, this configuration can ensure a link between cell sites when portables are used.

In urban areas, traffic demand can justify another cell site; however, the need for a narrowbeam antenna solution in this case is perhaps more important. In this environment we find portable users everywhere, especially in buildings. Again, since the narrowbeam directive antennas can detect a much weaker signal, better building penetration is obtained. This obviously applies to any area around the cell where coverage was marginal, so quality improves everywhere. A side benefit of the narrowbeam directive antenna solution is that if a mobile user stands by a window in a tall building, the mobile's signal can reach out too far. If the cell using the same channel has a narrowbeam antenna system, the chance of that mobile causing interference is only $^1/_{12}$ of what an omni cell site would experience, since there is only a one-in-twelve chance that the directive antenna is pointed toward that interfering mobile. Finally, in stronger signal areas, less power is needed. By reducing the power needed, battery-life can be extended, which equates into increased talk time.

Tx/Rx system adds capacity

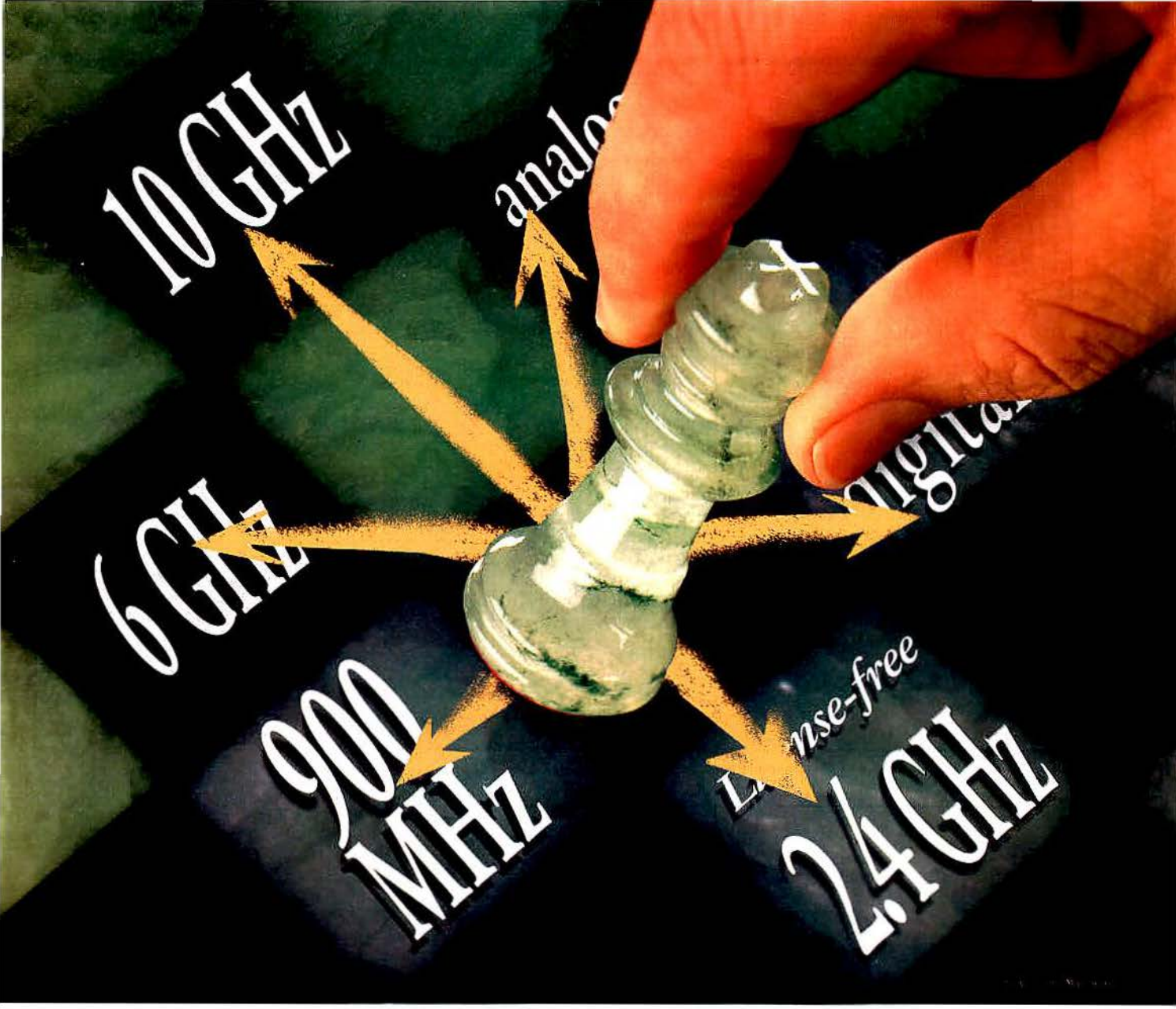
Adding transmission capability through a narrowbeam antenna provides the same reduced power benefit for the cell as it does for the mobile. However, the real benefit for the service provider is that the same cell can provide 30% to 100% increase in capacity. Because a narrow antenna beam is directed precisely at the mobile user, the amount of unnecessary and definitely unwanted signal energy that falls outside of the cell is reduced. The hardware and software are configured so that the best antenna signal for reception is also used for transmission. The second best signal on reception is routed to the radio diversity port. Test results have shown that this is an excellent diversity solution, eliminating the need for a second space diversity antenna. As mobiles move about, the directive antenna system constantly monitors the environment with independent scanning receivers that can be tuned to any channel in the system and connected to any antenna beam in a fraction of a second.

Simple antenna structure

Our system uses a panel antenna about 2.5 feet wide that actually produces four side-by-side, 30° antenna beams. Therefore, with just three antenna panels, a full 360° circular coverage is obtained. Each panel can be aligned to match a 120° sector for sectored cell sites, so the same antenna can be used for sector or omni. In fact, if propagation permits (or dictates) that a sector be larger or smaller than 120°, it is just a matter of adding or subtracting more 30° elements to define a sector.

Implementation

The most cost-effective method of



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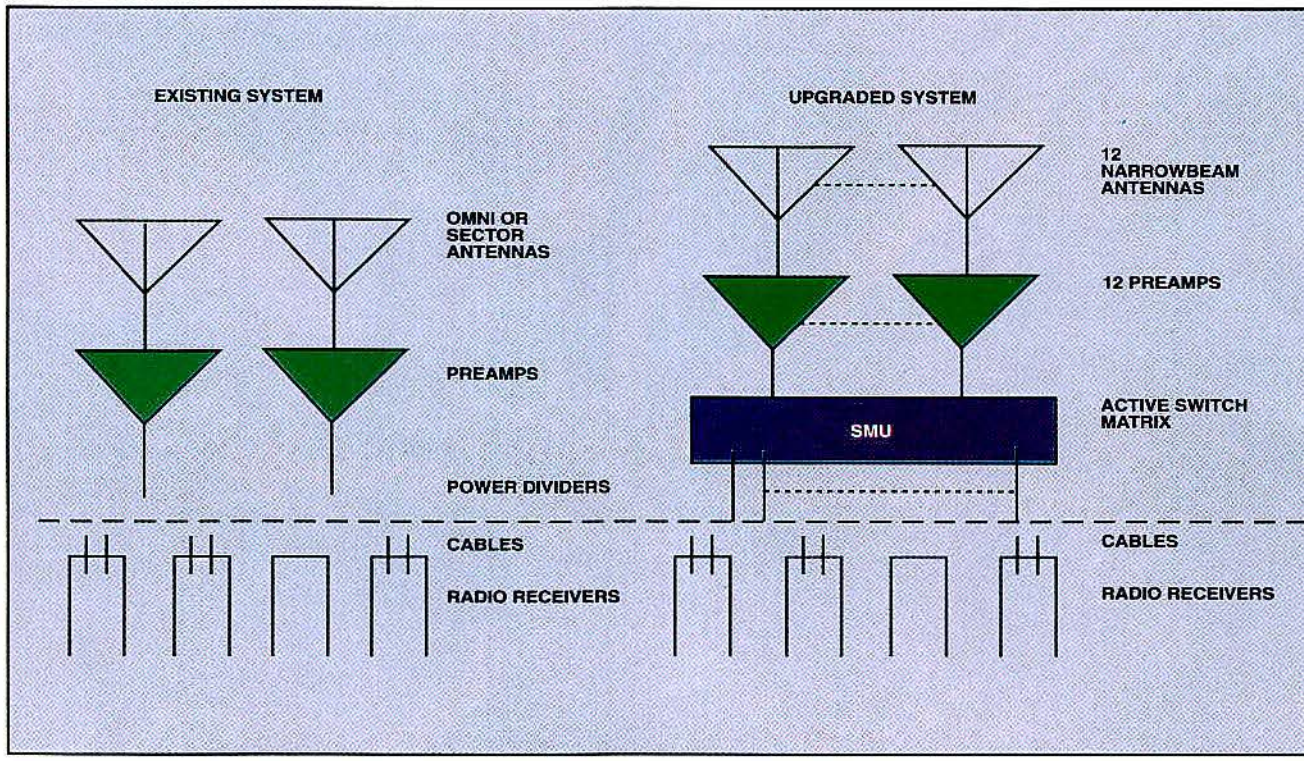

Figure 4. The intelligent antenna system implementation.

implementing a narrowbeam directive antenna system is as an appliqué on a cell site. The existing radio hardware and software doesn't know about the smart antenna system, it just works better. Figure 4 above shows how easy it is to implement for reception.

Transmission similarly routes the outbound signal through a spectrum management unit (SMU) and a linear power amplifier (LPA) to the proper antenna. The platform is designed to be modular because not all cell sites carry the same amount of traffic. Each plug-in SMU handles six radios. Each card cage holds six SMUs, and there is no real limit to the number of card cages. There is no requirement that a SMU be dedicated to a sector. In fact, by splitting up the SMU outputs, a worst-case failure of a SMU card would be a loss of only two radio channels in any sector. With a design objective of 100,000 hours mean time between failure for a SMU, there is no need for redundancy, except in extreme cases.

What comes next?

With the narrowbeam technology each cell site is designed to operate independently and to optimize its antenna beam system to best serve the mobile customers in its own cell. However, there are situations beyond the control of the local

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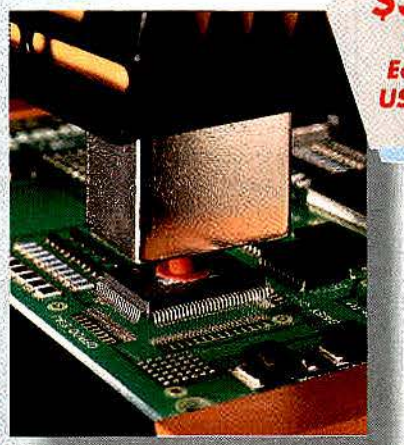

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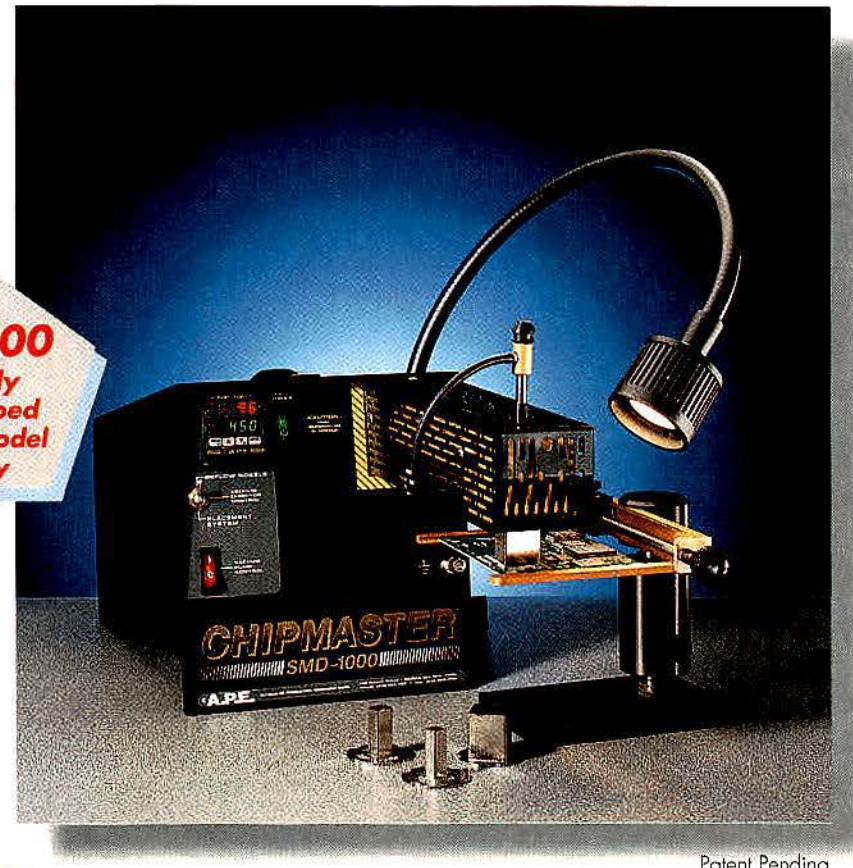

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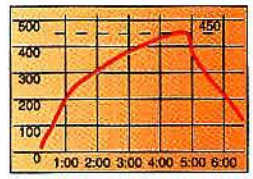

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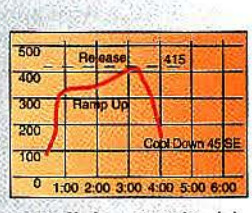

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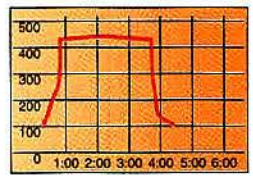

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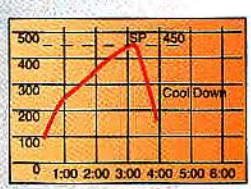

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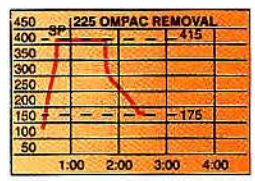

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cell site that provide opportunity to either increase capacity or reduce interference on a dynamic basis. Thus, each cell site's capability to report in real time to a host provides an opportunity to optimize the entire network. Actually, a close approximation to an optimum network can be obtained by looking at the activity of a cell and its nearest neighbors. A cell that has a problem with a particular channel on a particular beam can ask for help by sending this information to a host computer. The host can relay the information to the site causing problems for action. This relaying of information will lead to dynamic beam and channel assignments, which allows even tighter packing of cellular customers while retaining high cell quality. We have developed a networked product, MetaNet, that provides a central store for trouble reports, frequency planning, growth planning and records time data in minute increments and can log a map grid down to 0.1 square miles, if desired. The networked product is a platform for optimizing network performance while providing the capability for future enhanced services based on its distributed information routing architecture.

Where Does It End?

If and when analog dies (remember, there are 30 million analog customers today and still growing), will the narrowbeam technology work with a digital system? The answer is yes, for both time-division multiple access (TDMA) and code-division multiple access (CDMA). Although the solutions are different, the directive antenna allows you to pick up the reverse link advantages of narrowbeam antennas for either system. For TDMA, the switch matrix keeps in step with the time hops and switches over to the right antenna for the next mobile during the channel slot guard time. For CDMA, a pre-combiner configuration collapses the 12 beams into the usual CDMA sector configuration.

Both analog and digital service providers will be able to get the most out of their networks through the use of narrowbeam technology. The benefits of the narrowbeam technology will allow service providers to reduce cell site interference, to extend coverage and to increase capacity to serve the staggering growth of wireless customers.

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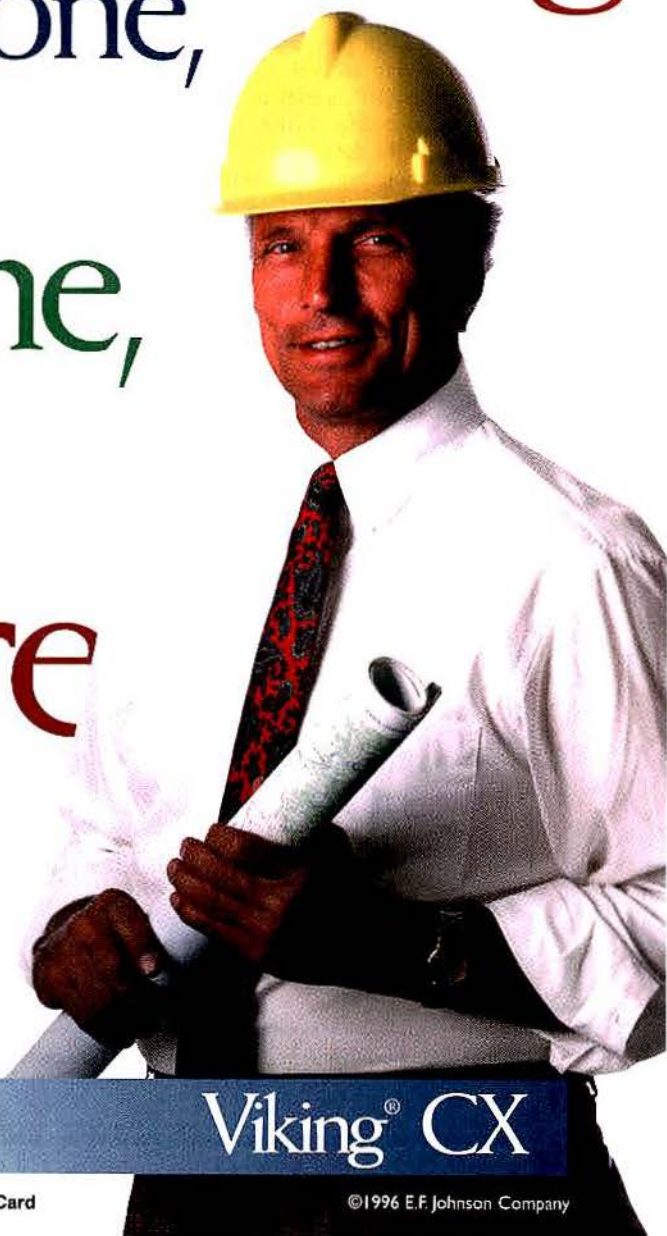

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Paging technology: Pager development, testing

Part 4—Three stages of pager development require various types of tests to verify performance. Here are some of the steps and the test equipment used in manufacturing and in quality verification prior to shipping.

By Lynne Stewart

Figure 1 below is a block diagram of a pager with receiving circuitry, digital decoding circuitry and devices that alert the subscriber and display a message.

The receiving section demodulates the data from the RF carrier and passes the data to the decoding section. The decoder then looks at the data and decides whether the information being received is for the subscriber. If so, that information is displayed on the pager, and the subscriber is alerted by the selected means—beep, vibration or flashing light.

Circuitry to "wake-up" the pager is most likely contained in both sections. Because the pager has a battery-saving mode, and depending on the paging protocol, the pager only "looks" for paging information during a particular point in time (as with Motorola Flex protocol and ERMES) or the signal being detected is what "wakes up" the pager (as with POCSAG and Golay sequential code).*

The receiving section consists of several components. (See Figure 2 on page 24.) First, an antenna receives the RF information. Oscillators, mixers, filters and amplifiers translate the RF signal to the baseband frequency. This translated signal is detected, and a serial stream of digital bits is presented to the decoding section.

The decoding section processes the information from the receiver. (See Figure 3 on page 24.) The microprocessor is the heart of this section. The microprocessor, with its surrounding circuitry, checks the incoming bit stream and determines whether it contains a message and what to do with it.

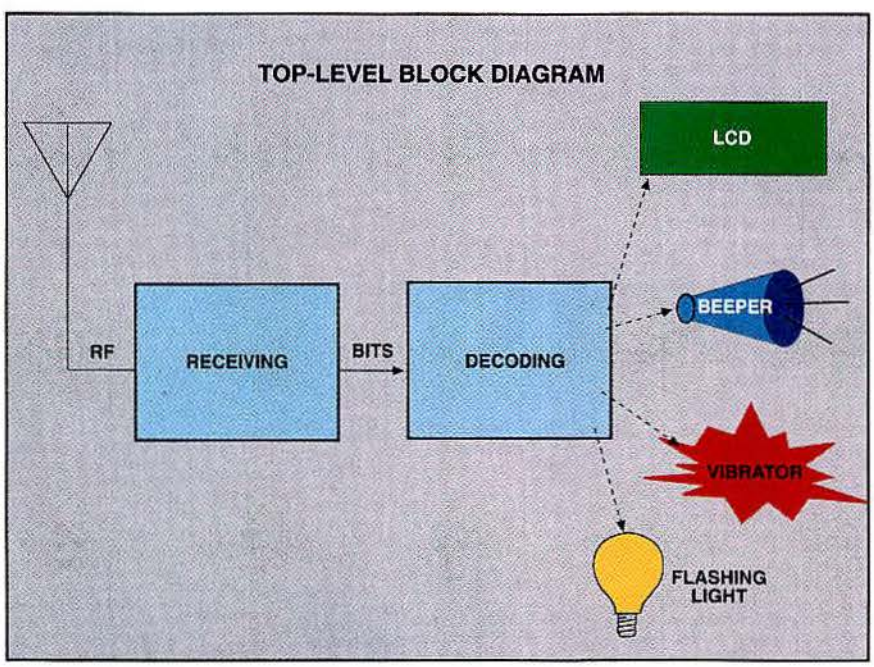

Figure 1. This block diagram shows how simple a typical pager is. Pagers usually include receiving circuitry, digital decoding circuitry and devices that alert the subscriber and display a message.

Paging technology series

Part 1: "Systems and Services," February 1996.
Part 2: "POCSAG, Golay Paging Codes," March 1996.
Part 3: "Flex, ERMES Paging Codes," April 1996.
Part 4: "Pager Development, Testing," May 1996.

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Pager development

There are three basic stages to pager development. These are *research and development (R&D), manufacturing* and *service.* (See Figure 4 on page 28.)

*Flex is short for flexible wide-area synchronous protocol.

ERMES stands for European radio message system.

POCSAG stands for Post Office Code Standardisation Advisory Group.

Golay sequential code is named after Marcel Jules Edouard Golay (b. 1902), a physicist who constructed the code about 1955.

Stewart is a market development manager with Hewlett-Packard's Microwave Instruments Division, Santa Rosa, CA.

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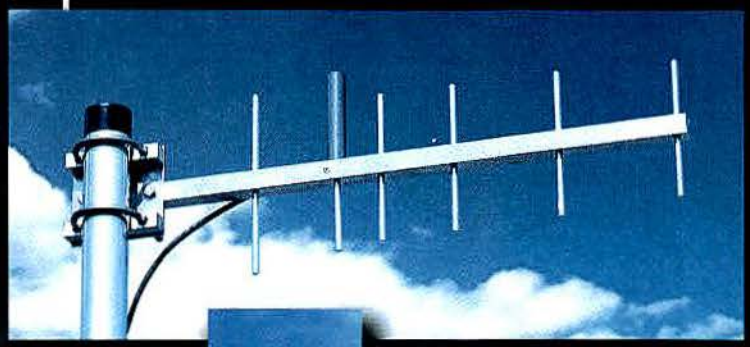

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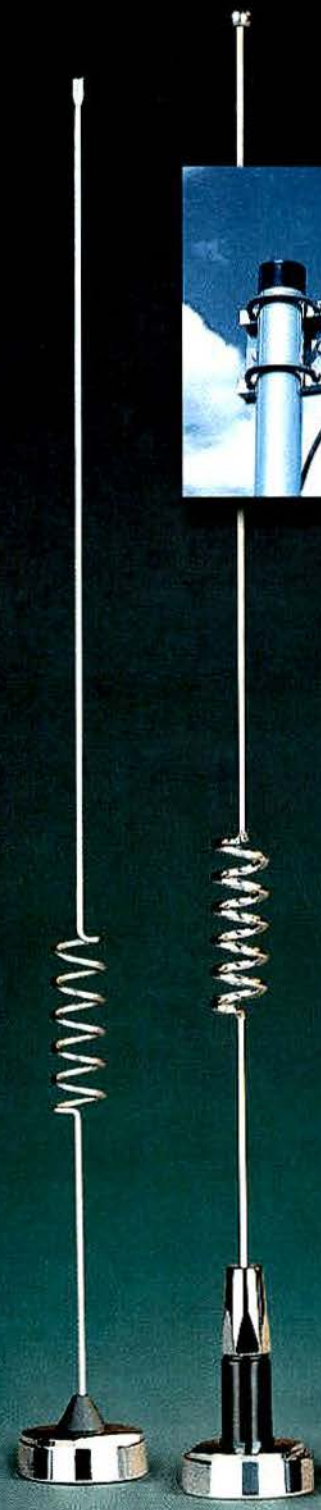

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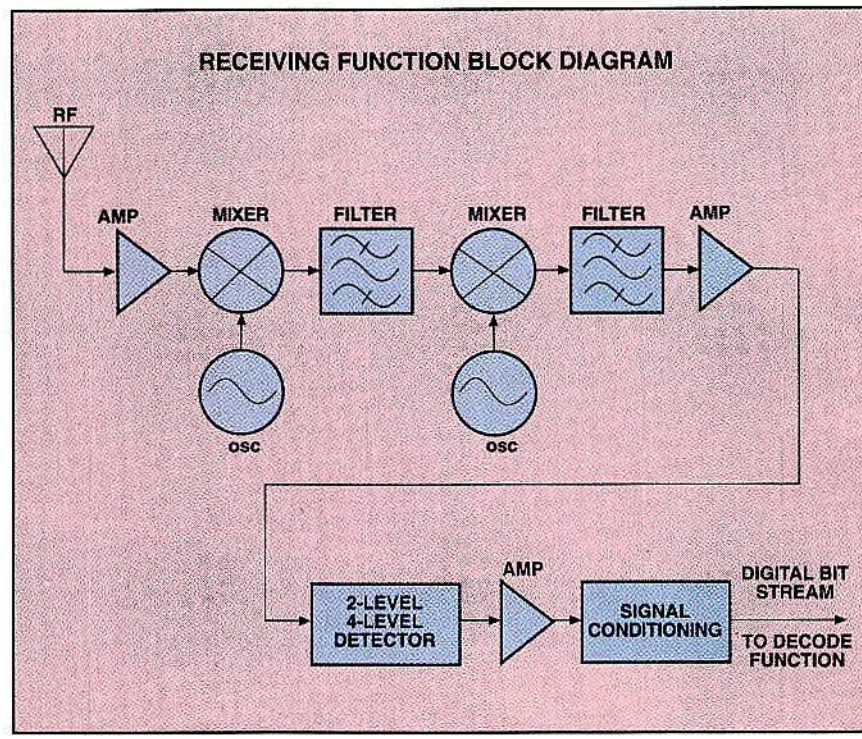

Figure 2. A pager's receiving section consists of several components. First, an antenna receives the RF information. Oscillators, mixers, filters and amplifiers translate the RF signal to the baseband frequency. This translated signal is detected, and a serial stream of digital bits is presented to the decoding section.

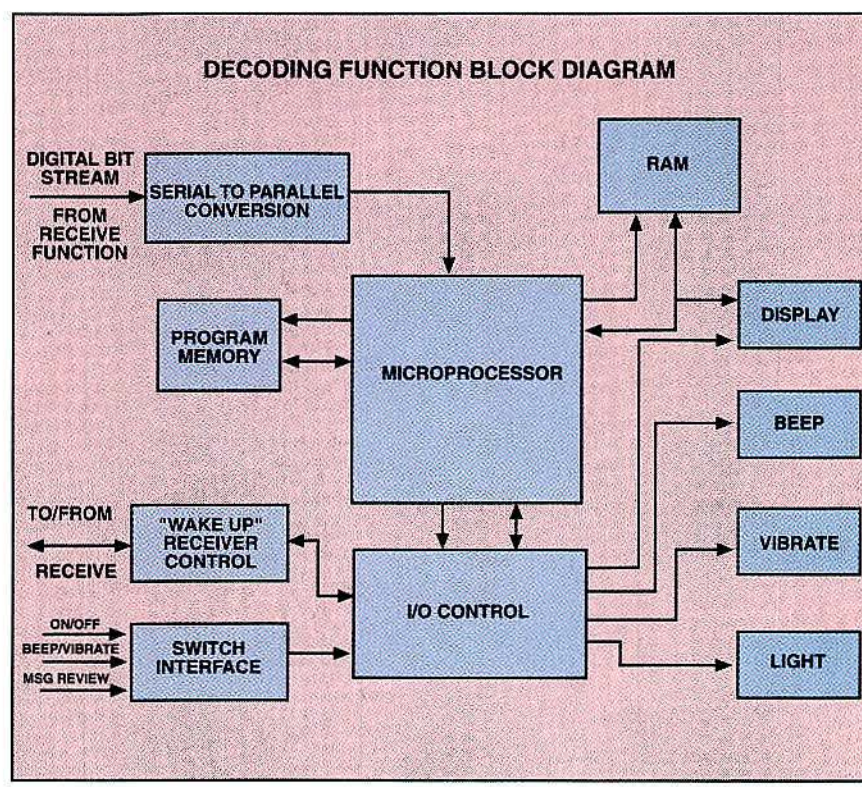

Figure 3. A pager's decoding section processes the information from the receiver. The microprocessor, with its surrounding circuitry, checks the incoming bit stream and determines whether it contains a message and what to do with it.

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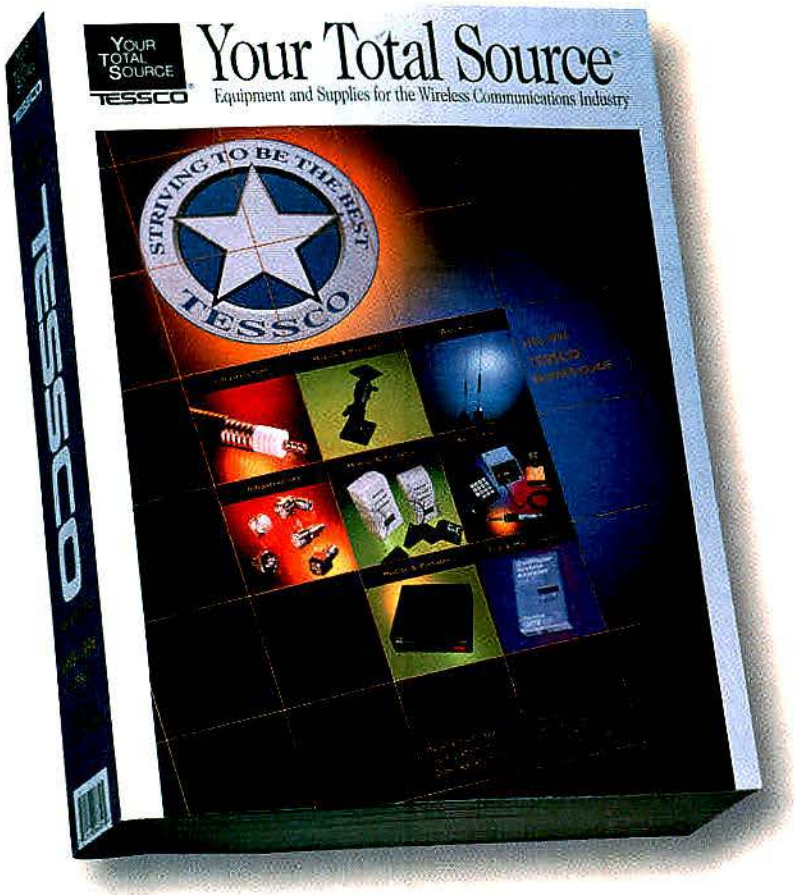

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103

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R&D workers design the pager and test a variety of circuit design characteristics. At this stage, the test objective is to thoroughly characterize all of the circuitry. Measurements must be made to verify performance, especially under varied environmental conditions such as temperature, humidity and shock. Typically, high-performance test equipment is selected for R&D work.

The objective of production testing is to verify that the product and processes are consistent. Meeting this objective results in high-quality shipments while minimizing production costs and meeting shipment and business goals.

A competitive pager manufacturer must always be looking for ways to reduce the production cost per pager. Testing must be fast, reliable and economical. The test equipment selected for the job must have the necessary measurement accuracy and repeatability to verify correct pager operation.

For pager tests in manufacturing, equipment ranges from basic tools to dedicated, one-box testers.

Parametric testing in production verifies the characteristics that vary from pager to pager. These are typically RF- and analog-dependent characteristics in the pager's receiving section and any process-dependent characteristics.

The final, functional testing is performed to assure that the end-user receives an operational pager.

Characteristics that do not vary from pager to pager do not need to be tested in production. These characteristics include those that have been thoroughly tested and proven during the design phase. They include most of the pager's decoding functions—protocol decoding verification, for example. Testing function in production provides no information about the production process.

Because a pager's receiver is intended to be selective and because received signal levels can be fairly low, its filters must be tuned to a precise center frequency. This tuning may be performed by a network or spectrum analyzer.

The oscillators must be tuned and aligned so that a precise intermediate frequency is achieved. Using the most basic tools, this test can be performed with a signal generator, encoder, frequency counter and voltmeter.

The pager must operate over a wide power range. Of course, the most important power test is operation at a low receive power level. Subscribers expect to receive their paging messages wherever they may be, and a sensitive pager is desirable. A sensitivity test can be performed

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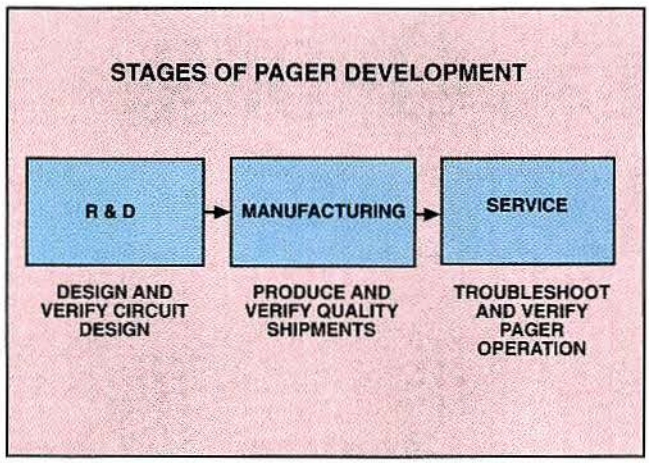

Figure 4. The three basic stages of pager development are *research and development (R&D), manufacturing* and *service.*

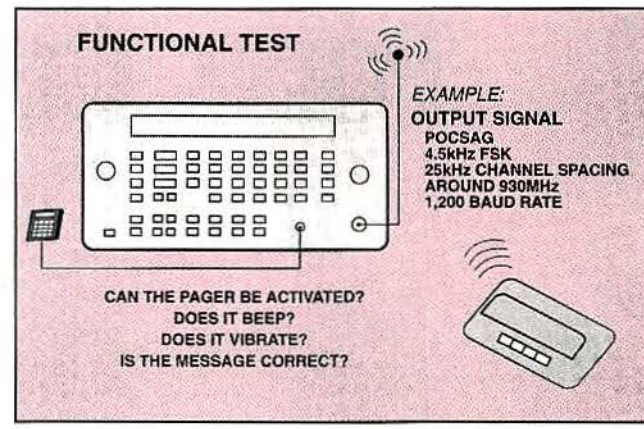

Figure 5. To accurately measure sensitivity without interference from other RF signals, the pager must be isolated. The use of a shielded room, isolation chamber or transverse electromagnetic mode (TEM) cell is highly recommended.

with a signal generator and encoder. To accurately measure sensitivity without interference from other RF signals, the pager must be isolated. The use of a shielded room, isolation chamber or transverse electromagnetic mode (TEM) cell is highly recommended. (See Figure 5 above right.)

A shielded room may be large enough for one or more test stations. An isolation chamber encloses the pager and test fixture. A TEM cell can be sized for pager testing. These are all recommended ways to achieve isolation. The differences among the three are their prices and the amount of space they require.

In final testing, before the pager is shipped, all of its basic functions should be tested. Does it beep? Does it vibrate? Does the light flash? Does it display the message correctly? The necessary test can be performed with a signal generator and an encoder.

This installment ends the article series.

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Active noise reduction: Advanced technology for improved communication

The key to communication is intelligibility. Overcoming environmental noise, line hum and other in-wire interference is becoming increasingly important for successful communication.

By Irene Lebovics

Intelligibility is the most important factor in mobile radio communication. Unfortunately, when radio communication is attempted in noisy environments, intelligibility is often lost. Low-frequency noise is most detrimental to intelligibility because, more than mid- and high-frequency noise, it masks other sounds including speech.

Active noise reduction (ANR) is the electronic manipulation of sound waves to reduce noise and enhance sound quality. One ANR method, the "anti-noise" approach, is the acoustic coupling of a noise wave with its exact mirror image. ANR is the only effective method of reducing low-frequency noise and is available today in "anti-noise" headsets for mobile radios that deliver unmatched clarity.

Another ANR method, which does not account for frequency, is adaptive speech filtering. This is the elimination of noise from speech and other transmitted and received signals and can be integrated into communications devices.

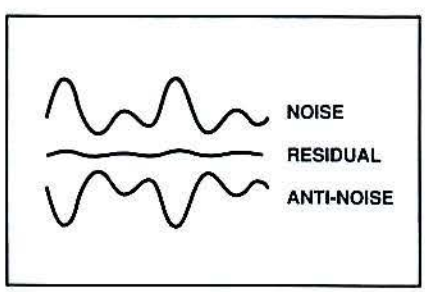

Figure 1. A noise signal, an anti-noise signal and the residual noise that results when they meet. Note that the active noise cancellation removes much of the noise energy from the environment instead of just masking the noise.

Lebovics is senior vice president at Noise Cancellation Technologies, Stamford, CT.

Photo 1. An open-back-style ProActive 1500 headset fits applications where low-frequency noise dominates.

Photo 2. A ProActive 3500 from Noise Cancellation Technologies fits high-noise environments.

The Technology

An ANR anti-noise system includes a microphone, a tiny computer (signal processor) and a speaker. The microphone picks up the signature of the undesired sound and transmits it to the signal processor. The signal processor analyzes the wave signature, creates its inverse (called "anti-noise") and, via the speaker, hurls it back at the original sound wave. If it were possible to achieve a perfect coupling of the opposing waves, the result would be absolute silence. Most frequently, because perfection is not achievable, a substantial noise reduction results.

Noise

Noise can be defined as unwanted sound. Sound is the result of pressure changes in air caused by vibration or turbulence. The amplitude of these pressure changes is the sound level (expressed as decibels or dB), and the rate of speed at which the pressure changes occur is the frequency (expressed as cycles per second or Hertz). Because the decibel scale is logarithmic, a small increase in decibels represents a large increase in sound energy. For example, an increase of 3dB represents a doubling of sound energy, and a 10dB increase represents a 10-fold increase. To the ear, a 10dB increase is perceived as a doubling in loudness.

Low-frequency noise

Prolonged exposure to noise, including low-frequency noise, is known to have detrimental psychological and physiological effects including:

- fatigue, anxiety and depression.
- loss of concentration and productivity.
- headaches, high blood pressure and hearing loss.

Low-frequency noise interferes with communication because it masks other sounds. Scientific studies have shown that

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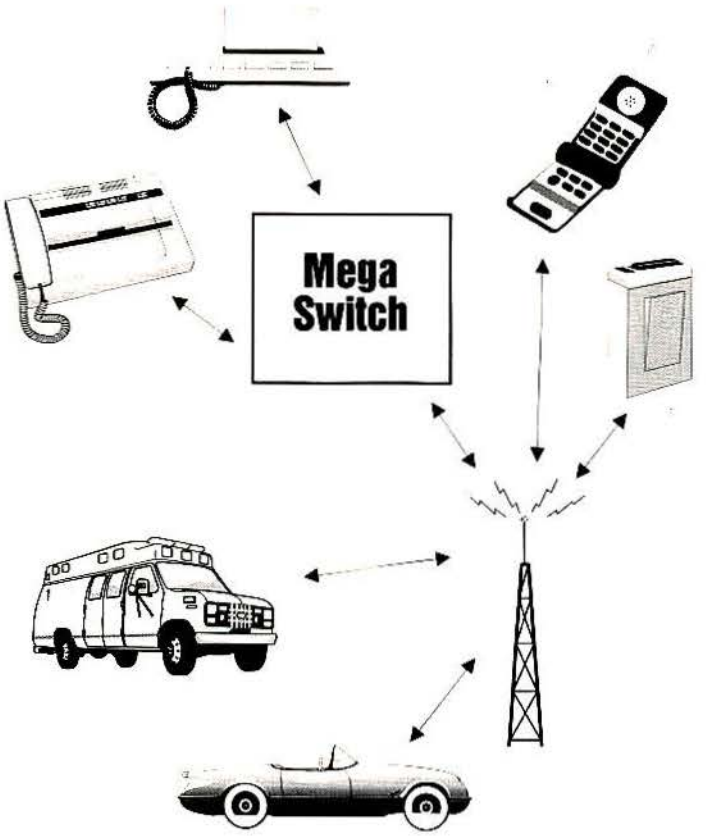

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an increase in the low-frequency component of background noise correlates to a decrease in speech intelligiblity. In environments where there is an abundance of low-frequency noise, people express the ability to sense another speaking, but not to understand what is being said.

Low-frequency noise from engines, motors and fans dominates ambient sound in most industrial settings. Oral communication in these environments is often crucial, making low-frequency noise reduction necessary.

Passive noise control

Passive noise control uses sound-dampening materials to absorb noise and vibration energy and to control its propagation. The use of sound-absorbing and rigid materials to reduce noise levels is effective with high-frequency sound. Below 500Hz, the cost, weight and mass of passive sound attenuation often make it ineffective or impractical. Therefore, another technique for noise control is required.

Active noise reduction

Although active anti-noise systems work across the full range of sound frequencies, most commercial systems treat low-frequency sounds—represented by buzzes, hums, booms and rumbles. Low-frequency waves are long, they travel extensive distances undiminished, and they can easily penetrate passive barriers.

The length of a sound wave is determined by dividing its speed by its frequency. For example, a 100Hz sound wave travelling at the typical 1,200 feet per second for sound in air has a ½-foot-long wavelength. When the peak of a noise wave is intersected by the trough of an anti-noise wave, the noise wave is completely cancelled. The sound waves are said to be exactly 180° out of phase. Some degree of cancelling is achieved even when the waves are not perfect mirror images—180° out of phase.

Passive noise control uses sound-dampening materials to absorb noise and vibration energy and to control its propagation.

Figure 1 shows the relationship in time of a noise signal, an anti-noise signal and the residual noise that results when they meet. Note that the active noise cancellation removes a significant portion of the noise energy from the environment instead of just masking the noise.

In most environments, noise exists in a wide frequency range. To attain the optimum level of noise reduction, it often is necessary to apply both active and passive methods.

Applications for communications

▶ *Active headsets* — One of the simplest, yet most effective applications of ANR can be found in headsets. ANR headsets provide as much as 20dB of background noise reduction in the low frequencies and, depending on the style,

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also provide a passive component for mid- and high-frequency noise reduction. ANR headsets provide a level of intelligibility and clarity that standard headsets cannot, because they reduce the low-frequency noise which most interferes with intelligibility.

Photos 1 and 2 on page 30 show ANR headsets. Models are available in both an open-back style for environments where low-frequency noise dominates and a closed-back style for high-noise environments.

▶ *ANR telephones and adaptive speech filters* — The most-often-used communications tool is the telephone. Using various applications of ANR, this tool can be greatly improved. By integrating electronics into a telephone handset or headset, low-frequency environmental noise can be reduced at the user's ear. This is beneficial when conversing on phones in noisy environments including factories, on telemarketing or trading floors and outdoors.

Dynamically adaptive speech filters represent another method of improving communications. In addition to the reduction in ambient environmental noise, dynamically adaptive speech filters continuously clean transmitted and received signals, attenuating background noise from speech.

This technology can now be cost-effectively integrated into two-way, mobile and AM/FM radios; telephone handsets and headsets; cellular phones; and even telephone networks to reduce environmental noise, static, line hum and other in-wire interference. Figure 2 above shows speech patterns, with and without noise, using this type of filtering.

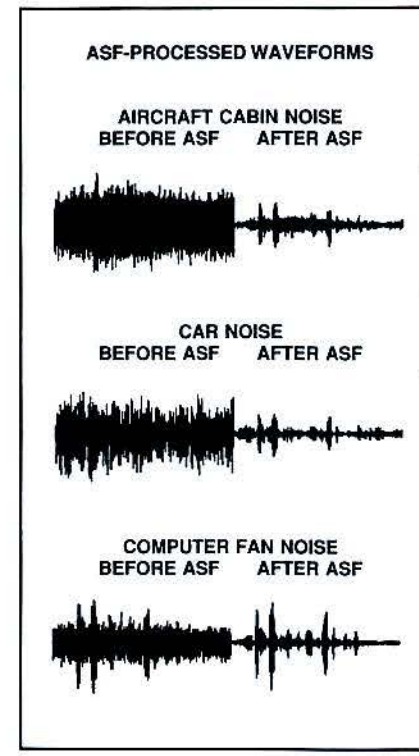
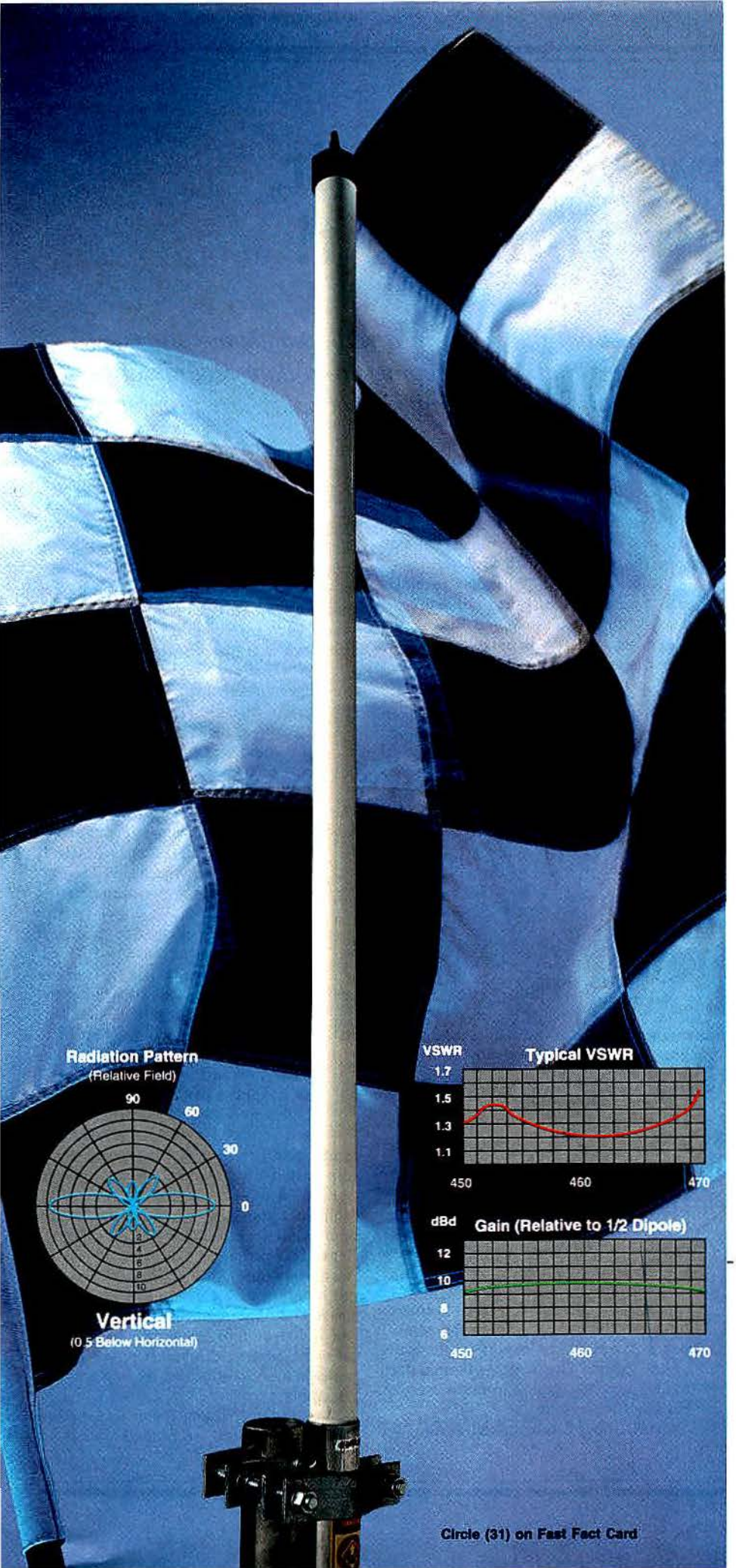


Figure 2. Adaptive speech filters remove background noise from speech and other transmitted signals, so noise frequency is not an issue. These speech patterns represent the noise reduction achieved in various environments.

The future

The key to communication is intelligibility, and noise from the environment, as well as line hum, static and other in-wire interference, is a major detriment to intelligibility. Only advanced technologies can address these noise problems, and as the world becomes a noisier place, ANR will become increasingly important for successful communication.



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Circle (31) on Fast Fact Card

Now you hear it, now you don't!

Bad weather sometimes brings out the worst in a radio communications system—or maybe it only seems that way. Keeping up-to-date records of equipment modifications and repairs help to troubleshoot rainy-day problems.

By Walter Rheingans

When it rains, it pours. Not just a logo on the salt box, mind you, but radio problems for the local county sheriff. It's one of those days when the rain just keeps coming down. We are all in the shop trying to keep dry when the trouble is first noticed. Ruben, the chief technician in this three-tech shop, is monitoring our most important, not to mention largest customer, the Sheriff's Patrol. He sensed trouble before the telephone rang. I'll bet you have days just like this one in your shop.

"Radio shop, this is Ruben, how can I help you?"

"Ruben, we got trouble," the sheriff's watch commander said. "With the storm, we are 'up to our ears in alligators' with traffic and street flooding problems, and the radio is not working right."

"I noticed on my monitor that some of your mobiles are cutting out," answered Ruben, "Is that what you mean?"

"10-4 to that, Ruben. I have 12 units out on the storm patrol, and some of them keep cutting out at dispatch, but they all seem to hear the dispatcher OK."

"We'll get right on it, sir," replied Ruben.

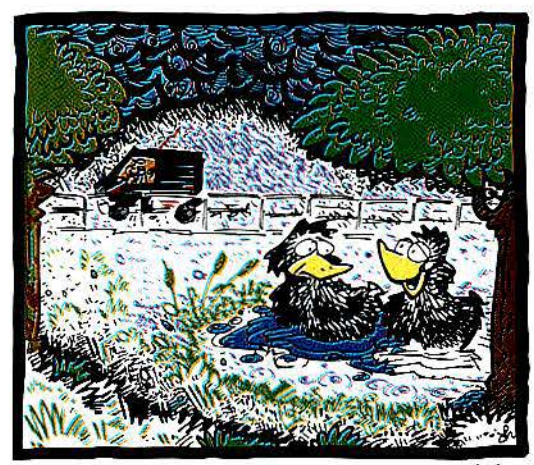
This is an unexpected problem, particulary because the shop recently had performed routine maintenance on the sheriff's entire system. The Sheriff's Patrol uses multiple-site simulcast transmitters and voting receivers—pretty standard for covering wide areas in law enforcement.

Rheingans is a free-lance writer in San Luis Obispo, CA.

"Well, boss," Ruben said, "we better put the staff on the go-plan and get 'em moving. The sheriff needs help now."

"Ruben," I asked, "what do you think—is it a vehicle or a system problem?"

"Couldn't say," answered Ruben, "but if we get someone to monitor the voter panel, maybe we can find out quickly.



"Hey Jerry, get over to the sheriff's equipment vault pronto and monitor the voter panel. The sheriff's in trouble and we need to troubleshoot the system."

"OK, I'm on my way," answered Jerry, heading out the door, umbrella, raincoat and test gear in hand.

It is only one block to the sheriff's equipment vault, and Jerry was there in a flash, watching the traffic on the voter. It didn't take him very long to see the nature of the beast. The watch commander's trouble was not coming from the mobiles, but from the system.

"Well, boss," telephoned Jerry, "tell Ruben the problem occurs when any mobiles or portables hit receiver site three. It doesn't matter which mobile is talking; when it is voted to site three it goes mute, and they lose it. I 'scoped the input to the voter, and the receiver stays muted and the vote tone is at the correct minus 20 dB's."

"Ok, Jer," I replied. "I'll send Karen to site three, and you stay there to do an end-to-end test. Keep the watch commander advised if you take any equipment out of service, OK?"

"Gotcha," said Jerry as he hung up.

Karen was not long getting to site three, including the preparations for a rainy day. The system is composed of Ericsson General Electric Mastr II UHF radio units at each site. The normal preventive maintenance is logged, and the site log is where Karen started looking. She thought it strange that the unit was just P.M.'ed, and now it was failing. The log showed that the unit had failed the CTCSS receive sensitivity test. This unit's P.M. test required 850Hz to 1,000Hz deviation to open the receiver on a test tone. A normal module requires a deviation level of about 250Hz to 300Hz. The entire module was replaced with one of the new units from Ericsson. The new design has dip-switch programming, where the old type used a Versatone frequency setting chip in a socket. The programmable design minimizes the spare parts stock problems, and perhaps equally important, the technician does not find arrive at site "A" with only a tone chip for site "B" in the parts box. The shop has been replacing the old-style units when they go bad. We also are finding the bench repair of the units is more costly than the replacement assembly.

At site three, Karen found that the old unit had been replaced with a

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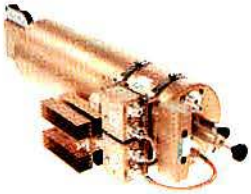

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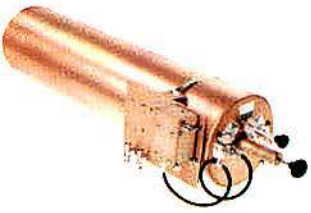

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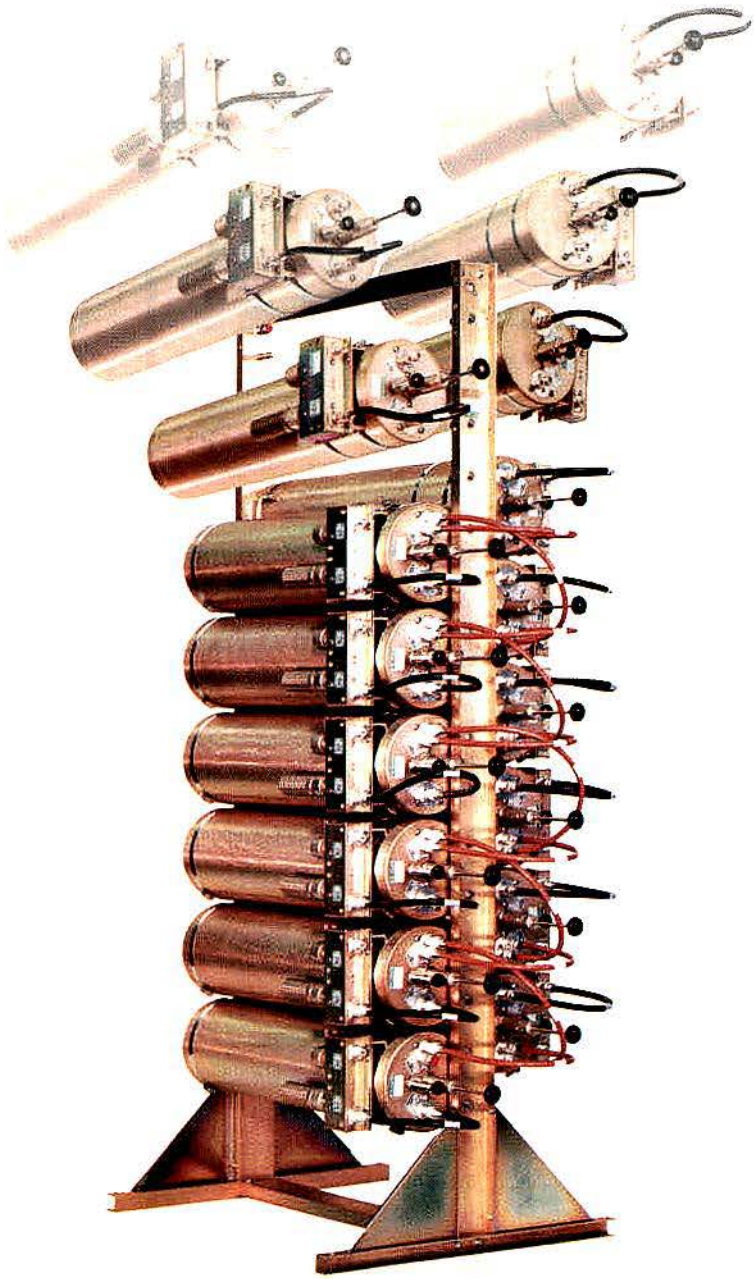

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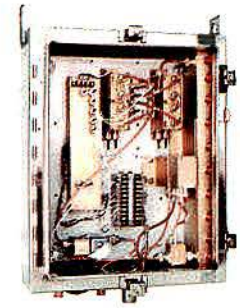

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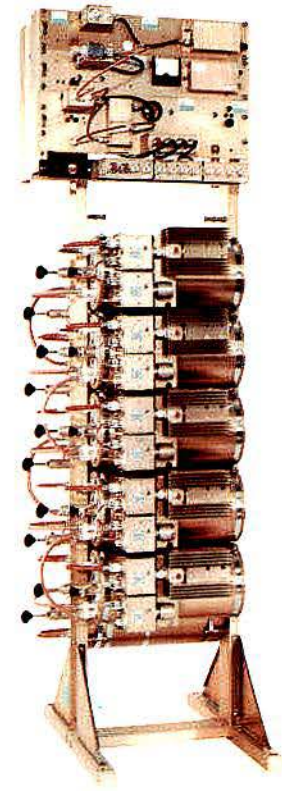

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19D432500G3. The G3, or group 3, is for decode-only and, operating as a duplex, four-wire audio radio, this site uses a decode-only and no-CTCSS on transmit.

"Hello," called Karen on the service phone, "are you there, Jer?"

"Contact," answered Jerry from the sheriff's main equipment room, "Whatcha need, kiddo?"

"Call the watch commander and get us permission to take site three out for a while so you and I can take a look at it, will ya?"

"No problem," answered Jerry, "I have him on the phone now, and we're clear for a 30-minute outage."

"OK, now will you disable the voter for this site and monitor the incoming audio on a test speaker?"

"Voter off, speaker on!"

"I'm setting up the 'IFR' and I'll give you some test tone. Here it is; what do you see?"

"Hey, hey, hey, Karen," Jerry replied, "I'm just getting a vote tone, not a test tone. Are you hooked up correctly?"

"You bet, Jer," confirmed Karen. "Whoops! Try again, I can hear the test tone on the service speaker. Can you hear it now?"

"OK now!" said Jerry.

"Well, I'll be darned. I got a test tone on the receiver and I hear it from the service speaker, and you get it at the voter too. Hang on while I check some more."

"Cool," said Jerry, "While you do that, I'll check the levels on the other channels. Holler when you need me."

"Re-enable the remote transmit line so the dispatcher can still talk off this site, and then don't get far from the service phone, Jer."

"I won't. Just holler when you need me."

Karen couldn't get a handle on the problem at this point, and went to the instruction book for the Mastr II. While looking through the book, she still had a monitor speaker on the line output. Something caught her ear. This sheriff's radio system returns all the mobiles' audio to all the transmitter sites and retransmits just as a repeater would, except it sounded to her like a classic case of desense. Mobiles would cut out, and the system would unkey, and they would be received again for a "click" and disappear again to repeat the cycle. She reached over and killed the remote transmit enable switch on the control shelf. All of a sudden she heard all the mobile traffic on her monitor speaker! No more sounds of mobiles cutting out.

"Hey, Jer!" exclaimed Karen, "Something weird is going on." "Do you still have the voter disabled from my site?"

"Sure, why?"

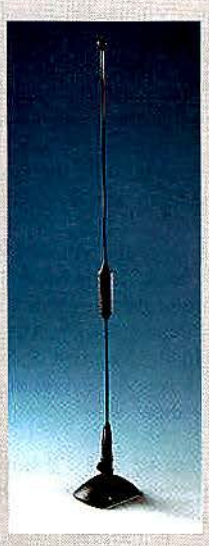
"Well, keep your monitor on the incoming line, and then when I give you a test tone, remote-key the transmitter and see what happens to the audio, OK?"

"OooKaay . . . It is keyed . . . . Whoowa! streamed Jerry, "When I keyed, the incoming audio from your receiver muted and returned to vote tone. Whatcha doing over there?"

"We have a receiver that is muting on transmit, Jer," said Karen with confidence. Call the shop and let's get some more info."

Jerry, Karen and Ruben were soon on a conference call, and Ruben put it on the speaker phone at the shop. Ruben got out the sheriff trouble and maintenance file. Meanwhile, I located the Ericsson General Electric Mastr II update file. At the site Karen referred to the Mastr II Instruction Book, and Jerry was just waiting to be helpful.

Demand Performance



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"Karen, you are in the drivers seat," I started, "The rain hasn't stopped, but it is otherwise quiet at the shop. Bring us up to date on the watch commander's complaint."

"Here's what we have determined so far, boss," began Karen, "The problem is certainly a system problem, and it is centered at site three. Furthermore, we have tracked it to a strange problem at the radio."

"Strange, how?" I interjected.

"Strange in that a radio suddenly starts to mute it's receiver when it transmits," she said, "and to me that is strange because muting is a fixed setup choice, and how can it change?"

"Yeah," added Jerry.

"What else have you found?" I asked.

"The log shows that Jerry P.M.'d this site last week," began Karen, "and the Channel Guard decoder was out of spec. He replaced it with a new one and returned the site to service as normal. No other trouble found. Right Jer?"

"Right as rain," chimed in Jerry, "The site worked fine when I left it last week. I followed the checklist and logged it all."

"Bet you didn't try the receiver with the transmitter keyed," Karen interrupted, "because that is not in our normal procedure. As I think about it, boss, I wonder if it has to do with the replacement Channel Guard module?"

"You are getting warm, Karen," I replied while looking over our notes in the E.G.E. Mastr II file, "Jerry, is the system still disabled?"

"Is now."

"OK, now Karen, you take the Channel Guard module out of the receiver so you can look at it, OK?" I requested.

"Got it . . . Am I looking for something, and is it on the front or back?" she replied.

"Foil and solder side," I told her, "where the connections leave edge jack J-908, pin 6 and go to hybrid U1002, pin 8; look to see if that trace is cut. Pin 6 is six in from the corner, with the corner starting as number 1."

"Nope, no cut anywhere," mused Karen, "Not there, not anywhere. Why are we looking for a cut?"

"Well, for now, take your tool kit scribe and cut through that trace," I instructed, "and replace the card and re-test with the system."

"Got it. Hey Jeeerrry," requested Karen, "Monitor for a test tone and then remote key the transmitter, OK?"

"Voter off," murmured Jerry, "monitor on, here we go . . . keyed . . . Eureka!"

"I think he's saying it works," Karen added.

"Well, 'another fine fix you've gotten us into' Karen," I said.

"You both forgot the staff meeting we had about two years ago," Ruben added. "The replacement decoders didn't work in a four-wire duplex system, because they mute the receiver line when they see a PTT on the bus. The PTT bus has to be cut on the decoder board, or, what just happened to our customer will happen every time!

"Karen, close the site; Jerry, call the watch commander and tell him the system is repaired and back in service," Ruben instructed.

"Jerry," I said, "Stop and get everyone donuts on the way back. Even better, you and Karen could bring donuts for a week. And pay attention during staff meetings."

"And cows could fly," replied Karen.

"Yeah," added Jerry, "and remember, we fixed it! How about you getting the treats?"

"Ok, you pick 'em up and I'll buy," I relinquished. "You guys did a great job on a rainy day. My treat!"

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The 220MHz systems: Too good to be true?

A technology that offers multiple advantages and carries a very competitive price seems too good to be true. Yet, according to many involved, the development and success of the 220MHz industry is at hand.

by Elsa Saavedra

When Richard Bell's family acquired six 220MHz licenses on the advice of their attorney in 1994 and started developing them, they realized the opportunity in purchasing other licenses and start developing systems. This marked the beginning of a new industry, the 220MHz systems industry.

A little background

The Federal Communications Commission (FCC) started giving licenses for 220MHz by lottery in 1992. This lottery was held so individuals could participate in the communications industry. Out off 6,000 possible 220MHz licenses, 4,200 were issued to people who did not have experience in developing systems. Immediately, a cellular owner in Atlantic City, NJ, brought a lawsuit because he believed he was not given enough time to allow him to participate. This lawsuit was not settled until 1994. Right after that, the FCC decided to establish a 90-day construction deadline.

By this time last year, 220MHz operators were struggling to have their systems fully constructed to meet the FCC's deadline of April 4, 1995. They knew they weren't going to be able to build out in that time frame because there was no available equipment, so they threatened to sue the FCC. As a result, the construction deadline was repeatedly pushed back. Finally, Dec. 31, 1995, was given as the final construction deadline, but the FCC shut down in December (along with the rest of the U.S. government). With the second *Report and Order* filed on Jan. 26, 1996, the final construction deadline was scheduled for March 11, 1996, unless a site needed to be modified, in which case, the deadline would be Aug. 15, 1996.

"By March 11 you either had to build in your original site, file the modification application or file a letter of intent to modify," explained Ralph Perez, president of MacMillan Communications, a 220MHz systems construction company based in Davie, FL. "They [the FCC] also gave some general guidelines whether modification applications would be accepted or not. Basically, if you are in the top 50 markets, you can move your site within an 8km range and be within the regulations. If you are outside of the top 50 areas, you can move your repeater 25km and still be within. So, if you follow the guidelines that were put forth in the Jan. 26 second *Report and Order*, you should be fine."

The regulatory uncertainty created by the FCC in the industry at the early stages of the licensing had an effect on licensees.

The regulatory side

The regulatory uncertainty created by the FCC in the industry at the early stages of the licensing had an effect on licensees. The FCC failure to begin accepting modification applications caused licensees to wonder if they would be able to obtain permanent authority at sites where they have obtained Special Temporary Authority (STAs) to construct. Additionally, the FCC determined that licensees constructing at sites other than their licensed sites, pursuant to STAs, wouldn't be considered to have been constructed if they couldn't eventually obtain permanent authority at the new site. This regulatory uncertainty also had an effect on manufacturers, who didn't aggressively pursue manufacturing the needed products.

"There has been a lot of progress in the last months," said Bill Luckett, project engineer with Incom Communication, a system construction company based in Anaheim Hills, CA. "The *Report and Order* that came on Jan. 26 clarified many of the rules that were causing uncertainty in the industry and cleared up a lot of the questions. Now we are moving along to complete the rest of our constructions." Additionally, said MacMillan's Perez, the STAs are not issued anymore, now, just a modified application is needed, and all the ones that were filed as Jan. 26 are basically granted.

Other problems?

In the beginning, it was thought that some potential problems, both technical and construction-related, would be arising as 220MHz systems started operations. However, operators and manufacturers were convinced that these problems could be solved. As of today, it seems that operators and manufacturers were right, and no major problems have stopped the development and success of this young industry.

According to Incom's Luckett, they have not experienced any problems with equipment, and they have been able to construct and operate their systems with no major setbacks. He mentioned that with additional filtering in the equipment, they have been able to eliminate any noise and co-channel interference. MacMillan's Perez said "If the engineering is done correctly on the site, you

Saavedra is an editor with Intertec Publishing.

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shouldn't have problems when you install it [your system]."

The market

End users of 220MHz services are people in the dispatch market who use point-to-point, mobile-to-mobile and mobile-to-office type of communications. "Our users are any service-oriented type of business such as construction companies, courier services, public safety and highway patrols," said Pam Baker, national sales manager for Incom Communications. "Basically, we can provide better service than some of our competitors in other frequency bands due to the nature of the 220MHz frequency itself, and the way it travels, so to speak, covering wider areas. They [the users] are not paying for something that they are not using. We can provide them with a simple dispatch system that can give them what they want, which is wider coverage and privacy."

Applications

As a low frequency, 220MHz presents many advantages such as in-building use, as well as outside use. It has better propagation than 800MHz and 900MHz in heavily wooded areas and over undulating terrain.

MacMillan's president, Perez, mentioned an unusual application for 200MHz service: a hospital robot that delivers food and items from room to room. "This little robot needed to communicate with the elevator, so he could get inside and go from floor to floor. The company which provides those robots came to see us about putting a 220MHz radio on the robot, and a 220MHz radio on the control panel of the elevator, so they could communicate. One of the reasons they wanted this type of equipment is because 220MHz works better inside buildings and behind concrete than 800MHz or 900MHz."

Ron Domres, Incom Communication's president, explained that there will be a significant need for point-of-sale data in the future. He mentioned that Incom is already working with some users that work primarily with data, supplying them with a radio that provides voice as well as data. In addition, Incom is providing them with mobile data terminals and customized software programs written specifically for their industries. The result is that the end user who is driving a vehicle can take credit cards and ATM cards instead of having to carry cash. End users can easily communicate from their vehicle via the computer and use different types of peripherals such as printers.

Success of 220MHz systems

A technology that can make radio communications more transparent, that can improve response time, achieve excellent production from available resources and still be affordable, has to be a success, and it seems that the 220MHz systems can deliver just that.

Incom's Baker said "We are providing voice and data communications. Our users are able to take one piece of equipment and utilize voice as well as data. There are not that many carriers that can offer that."

"It is very rare in the industry that someone can provide [the users] the best quality service at the smallest price," said MacMillan's Perez. "Compared with other systems we [the 220MHz] go further; systems have clearer communications, a clear signal and can also provide more features. The radios that we use have 26 data functions that you can set instead of voice, according to your needs. We just offer the cutting-edge technology at the lowest price."

Perez said the fact that licenses were given to people who didn't have experience in developing systems presented an opportunity to companies such as his, which was able to offer its services assisting these inexperienced people in managing their systems.

Future of 220MHz systems

"This market is going to explode, because in many of the major markets, 800MHz and 900MHz frequencies are already jam-packed," said Perez. He thinks that as soon as the data application comes on line, demand for data services will exceed demand for voice services..

Incom's Domres said the 220MHz technology is successful now, and will continue to be, because it is aimed at the dispatch user who doesn't need all the "frills" that other technologies, such as cellular, offer. He said this technology is perfect for the company that needs just a brief answer from the vehicle that is away from the office, and a price that is affordable, so the user can easily justify the investment.

Too good to be true?

A technology that offers the ability to hear and be heard, at any time, from anywhere, that offers instantaneous connection, excellent range, wide area coverage, high-quality audio, that can handle several tasks, and carries a very competitive price seems too good to be true. However, Richard Bell's family thought that developing 220MHz systems was a *good* idea, and time is telling us that it seems *to be true*.

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Report light outages with tower site monitor

A dial-up monitor fulfills FCC requirements for monitoring proper tower light operation and reporting outages, along with providing some additional monitoring and remote control functions.

By Larry Quigley

Unreported tower light outages can cost a tower owner a lot of money in federal fines if they result in a fine levied by the FCC. Non-tower owners with FCC licenses who rent space at tower sites for communications antennas have been relieved by the FCC of primary responsibility, but in the event the tower owner fails to act, tenants might still incur a liability.

Aside from monetary forfeitures, reducing the potential for a serious aviation accident is enough motivation for reputable tower owners and communications system licensees to maintain tower lighting in good working order.

Some people with the responsibility for tower lights rely on someone else to make a daily observation of those tower lights and to report any outages that may be observed. The method is as unsophisticated as having someone look at the tower each evening to see whether the lights are working. If for one reason or another the observer fails to perform that duty, outages may go unreported.

Early automated light-checking and monitoring systems were expensive and were subject to failures caused by utility power outages and lightning damage. Today, many good automated systems are available. Systems can be installed to use leased telephone lines, the public switched telephone network (PSTN or dial telephone) or radio links.

The tower light monitor can be used for remote control purposes, too.

One of the most reliable ways to monitor tower light operations uses the dial-up telephone to report outages. When this system has a battery backup, a report can be made even during a power failure.

A tower light monitor actually can become a site management reporter, reporting not only light outages but multiple light outages, illegal entry and water on the floor, to name a few events. One such monitor plays as many as four voice messages to whoever answers the phone telling what the problem is. The unit calls three numbers, rotationally or once through, to give one of the four messages.

Setting the monitor to call three telephone numbers in sequence works well when at least one of the numbers always is answered. If sometimes none of those numbers can be expected to answer, then rotational calling should be used. Rotational calling dials each of the numbers, over and over, until someone answers and stops the calling action by dialing a "stop" code.

Also, the monitor itself can be dialed from another telephone and can be tested from any dual-tone, multiple-frequency (DTMF or Touch-Tone) telephone.

The unit is programmed with a built-in telephone keypad. Voice messages are recorded using a built-in microphone. The program memory is non-volatile, so telephone numbers and voice messages remain in memory for a minimum of six weeks with no power applied and no battery backup.

A current sensor can be used with lighting systems that do not provide a contact closure for a "light out" condition. The current sensor is adjustable so that one bulb failure out of many bulbs on one line can be sensed to initiate an outage report.

The tower light monitor can be used for remote control purposes, too. A DTMF telephone can be used to enter various control codes for as many as eight functions. Outputs include latching or momentary contact relays that can be programmed for latch, momentary contact, toggle or multiple resets.

A dial-up tower light monitor can offer an inexpensive yet reliable way to fulfill FCC requirements for monitoring proper tower light operation and reporting outages, along with providing some additional monitoring and remote control functions.

Quigley is president of Bramco, Piqua, OH. Bramco manufactures the dial-up tower light monitor described in this article.

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Digital radio supports wireless communications at 1996 Olympic Games

Without the ease of reliable communications, coordinating this world event would be extremely difficult. An innovative wireless communications system helps to bring mass media coverage to the largest world audience in history.

By Mark Moon

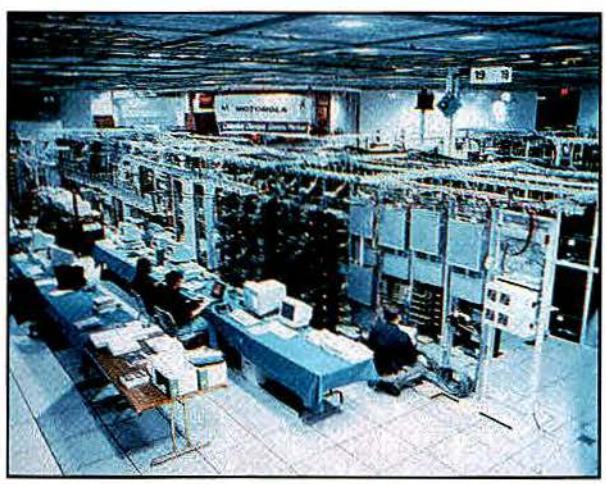
In what became an inspiration for runners everywhere, Pheidippes, a Greek soldier, ran 23 miles from Marathon to Athens to relay news of victory against the Persian forces of Darius the Great. That was in 490 BC. To honor this hero, the modern Olympic Games created the marathon competition, forever establishing the symbiotic relationship between athletic achievement and communications.

During the past century, since the rebirth of the Olympic Games in Athens in 1896, the Games have consistently grown in size and scope. This summer's Centennial Olympic Games are remarkably different from the first modern Games. Only 311 athletes from 13 countries attended those first events. More than 10,000 athletes from 197 nations will participate in Atlanta in 1996. And although only about 100,000 fans watched the original Games in Athens, more than 2 million will enjoy the Games in Atlanta. In addition, it is estimated that two-thirds of the entire world population—3.5 billion people—will watch some portion of the Games on television.

To put it in perspective: The Centennial Olympic Games in Atlanta will be the largest sporting event in the Twentieth Century. Managing the event will command resources equivalent to staging 12 Super

Moon is Motorola director of system technology for the 1996 Centennial Olympic Games.

Customer's Center for Systems Integration



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After the customer and our company's team plan each site and verify its footprint, the center's documentation group details all component layouts and produces site diagrams and equipment, cable and wiring schematics.

Once the network is assembled, the CCSI team conducts a step-by-step functionality test with the customer, keying the radios, activating channels and testing the console positions for dispatch capabilities. The team then conducts real-life scenarios to review potential failure modes, a procedure repeated on-site after the network is installed. The result is a thoroughly tested and refined system ready for easy installation and reliable service.

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Bowls in one city—in one day—for 17 days.

Complementing this increased athletic participation and larger world audience, wireless communications technology has become an indispensable tool in executing the Games, training the athletes and communicating their triumphs. My employer, a partner-level sponsor of the Centennial Olympic Games, has been active at various levels of Olympic sponsorship since 1972 and has been a primary catalyst in the development of wireless communications for the Olympic movement.

The heart of our partner-level commitment to the 1996 Olympic Games is embodied in a state-of-the-art FM digital two-way radio network. It will be the largest and most sophisticated two-way radio communications network ever to be employed at an athletic event.

The Olympic Games network is designed to meet the extensive communications needs of the tens of thousands of staff and volunteers who are responsible for security, transportation, event management and countless other concerns. The "backbone" radio system will be supplemented with our pagers, cellular phones, computer modems and secure two-way communications equipment.

Communications devices include 10,000 mobile and portable radios, 6,000 alphanumeric pagers, 1,500 cellular phones and 1,500 modems.

Customer needs analysis

To get the most accurate sense of what demands would be placed on the communications network, extensive groundwork had to be laid early in the design process. Working in concert with members of the Atlanta Committee for the Olympic Games (ACOG), we conducted extensive research into ACOG's requirements for the successful operation of the Centennial Olympic Games.

This needs-analysis defined and clarified ACOG's basic operational concerns and communications objectives and revealed its key performance requirements before the process of network-building could begin. Essentially, a network designed for a large-scale event such as the Olympic Games has to effectively manage communications among thousands of users.

We started the needs-analysis process for defining the wireless communications network more than four years ago. Network designers and engineers met with ACOG staff, and two of our technology executives were "loaned" to the organization to drive technological development.

The network required meticulous planning across the board, and it was very much a "learn-as-you-go" situation.

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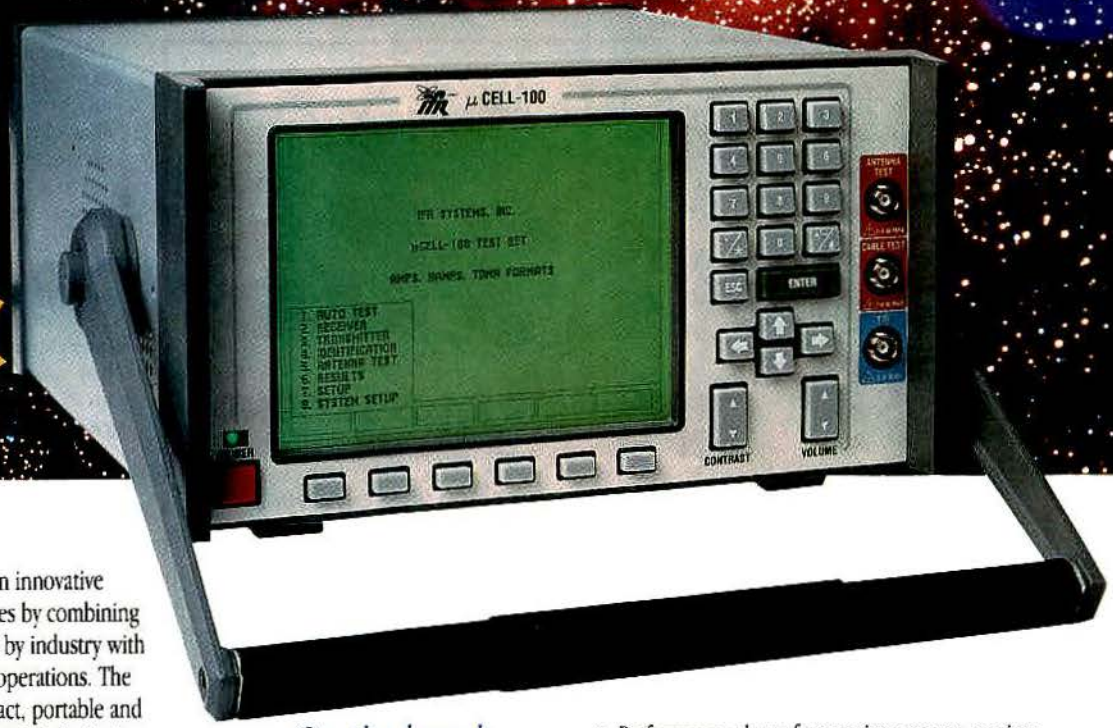

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Because advancements in two-way communications technology have paralleled the growth in size and scope of the Games themselves, we could not assume this network merely required refining previous solutions, such as the one used in Los Angeles for the 1984 Summer Games.

The Los Angeles network served competitive venues and facilities spread out over an area with a 100-mile radius. At the time, the availability of radio frequencies was not a pressing issue. Trunking technology was just coming into its own during that period, and the concept of a two-way trunked radio network, which we implemented at the 1984 Summer Games, was an innovation slightly ahead of its time.

The Atlanta Games' needs were more complex to define than those in Los Angeles 12 years ago. The technological solution that worked for Los Angeles would not work for the Atlanta Olympic Games.

Seventy percent of Atlanta's Olympic Games activity will be concentrated in the Olympic Ring, an area in the city with a 3-mile radius. The remaining events will occur throughout the state and across the Southeast. A network had to be designed to accommodate operations in both the metro area and in the remote venues.

In addition to immediately apparent differences in the Games' geographic locations, the Atlanta Games' communications network also had to contend with a relative scarcity of available radio frequencies and, at the same time, had to accommodate more than twice as many users as the Los Angeles Games network. These factors created a whole new set of operating characteristics that would have to be addressed when in the network design.

Once these initial factors were determined, network designers conducted extensive customer research to obtain an accurate impression of ACOG's vision for the network's performance. In October 1994, our engineers and executives began interviewing the future network users, getting an immediate sense of their communications needs and operational plans. This gave us essential impressions of ACOG's operational plan and ACOG's intended use of its communications equipment to its own effectiveness.

As we were clarifying ACOG's communications needs, we also determined that, in addition to being extremely efficient, the network would also have to interoperate with area public safety agencies. Such interoperability capabilities will allow ACOG to interact with law enforcement and emergency response forces at every venue of Olympic Games competition.

The needs analysis considered all these elements. Using this information as the starting point for the network's development, we began building the communications system that would meet ACOG's needs.

The resulting recommendations called for a flexible, highly sophisticated network built on our Astro FM digital two-way radio platform. Similar to the many large-scale public-safety systems that we have designed for federal, state and local governmental agencies in the United States and worldwide, it is the foundation for ACOG's wireless network.

The essential systems operating in the network are Smartnet II digital trunked simulcast systems. A six-site system will serve the extended metro Atlanta area. Another two-site system will operate throughout the Olympic Ring. A single-site system will be installed in the Olympic Village at the Georgia Institute of Technology to coordinate on-site logistics


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and operations. These systems, although independent of one another, will be tied together through our SmartZone technology for full, wide-area connectivity. For example, a user in Stone Mountain Park, 16 miles away, will be able to speak with a user at the Olympic Stadium.

In more remote locations, stand-alone radio systems will serve the needs of each venue outside of the metro Atlanta area. Finally, two Motorola Advanced Systems Communications Trailers (MASCOT) will provide transportable trunked radio systems for maximum flexibility to handle communications at various locations prior to and during the Games.

System integration, site preparation

Once our company and ACOG had determined the specifics for the network, many technicians and engineers began the process of integration. A key to this successful phase assembly was our Customer's Center for Systems Integration (CCSI).

The Motorola Advanced Systems Communications Trailer (MASCOT)...

...and one of the operating positions inside the trailer.

The 38,000 square-foot CCSI, located at our Schaumburg, IL, headquarters, allowed us to perfect the network to ACOG's exacting specifications while it essentially still was on the factory floor, close to all necessary technical personnel and resources. The CCSI facility allows customers to completely test wide-area communications systems exactly as they will reside in their installation locations before they are shipped from the factory.

The CCSI was fundamental to the successful development of the network, which we began constructing on Sept. 5, 1995. In less than three months, the network was staged and tested to ACOG's satisfaction. Without the ability to stage a network of this complexity at the CCSI, it would have taken more than twice the amount of time and personnel to complete the Olympic Games' network.

With the network fully tested and shipped, ACOG and our company have started preparing the infrastructure installation sites. Overall, three wireless communications towers and six equipment shelters will be constructed for the network, supporting network controllers, 250 repeaters and ancillary equipment such as antennas and transmission lines. The tower construction was scheduled for completion in January. The remaining equipment storage sites and remaining infrastructure components were scheduled for completion in February, with final testing of all

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Bandwidth:	2MHz minimum
Pattern:	hemispherical
Polarization:	RHCP
VSWR:	1.5:1 maximum
Input Impedance:	50 Ω

ELECTRICAL SPECIFICATIONS MODEL GPSA

Description:	active receive GPS antenna
Center Frequency:	1572.42 MHz
Bandwidth:	2 MHz minimum
Pattern:	hemispherical
Polarization:	RHCP
VSWR:	1.5:1 maximum
Input Impedance:	50 Ω
Preamplifier Gain:	16dB typical
Noise Figure:	2.5dB maximum
Passband Width:	20MHz minimum
Preamplifier Power:	24 mA @ +5 volts (nominal)
Operating Temperature:	-30° C - +85° C

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Cable:	15ft. Rg-7000 standard; RG-174 optional
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sites scheduled for completion by April.

Preparation for the Games

With the network designed, tested and in the initial phases of installation, now we are preparing for the Games themselves. With the summer approaching rapidly, the network's users must be trained, devices must be programmed and the equipment must be field-tested to ensure overall satisfactory operation.

To complete this phase, nearly 10,000 mobile and portable radios functioning on the network were to be shipped to their operation sites by early spring. Once there, they were to be programmed by a team of 20 technicians to match their operability to a pre-established "fleet-map," that defines the devices' areas of functionality.

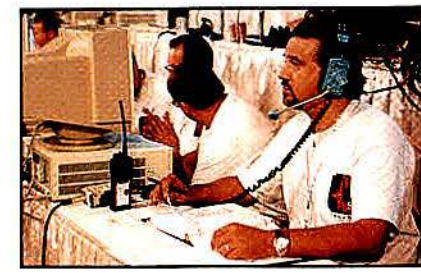
After the devices have been programmed, users are taught how to operate them. Throughout April and May, ACOG staffers, designated as communications technology "champions," are to be trained so they can in turn train the remaining network users. We also are designating training videos for each particular communications device to provide users with easy-to-follow directions on how their communications devices perform, and how each device will enhance users' effectiveness.

To complement the training and the video, each device—two-way radios, pagers and cellular phones alike—will have an accompanying help-card listing tips for easy device operation. A radio distribution center will be located in each venue for additional backup and support. Controlled by the venue's radio communications manager, the center will have spare parts on hand for immediate replacement and a spare battery for every radio issued. It will facilitate efficient, decentralized inventory control and distribution management.

To support network operations, we will also have about 100 service technicians onsite working with ACOG staff throughout the 17 days of the competition to manage network operations. System managers will monitor network activity around the clock, and additional employees will be on hand to lend technical support.

Incorporating related technologies

In addition to this cutting-edge digital two-way radio network and nearly 10,000 mobile and portable radios, we are incorporating other related advanced communications technologies into the overall Centennial Olympic Games communications effort. We will also supply 6,000 alphanumeric pagers, 1,500 cellular phones, 1,500 computer modems and secure two-way communications equipment.



Two-way radios and computer modems support communications at the Atlanta Olympic Games.

Included among these communications technologies is our Integrated Dispatch Enhanced Network (iDEN), which incorporates four communications services (voice dispatch, full-duplex telephone interconnect, text messaging and future data capabilities) into one network—operating on one device. For the Games, its wide-area capability was an ideal way to meet the needs of the Olympic Family transportation system.

The cellular phones and pagers will be used throughout the Games, meeting the diverse communications needs of each event venue. These responsibilities will include security and transportation, as well as event management needs such as medical support, event scoring and timing, judging, and food and beverage services.

The computer modems will link the computers throughout each venue, connecting them to provide reliable, rapid information exchange, while the secure two-way communications equipment will serve the Olympic Game's security forces via the landline telephone network.

Looking ahead to summer

Throughout the last century, the complexity and effort required to execute the Olympic Games has paralleled the Games' ever-increasing exposure and appeal. Fortunately for the world's eager Olympic fans, the technologies that make it possible to stage such a dramatic event on such a grand scale have evolved to keep pace with the Games' popularity. Without the ease of reliable communications, coordinating this global event on such a scale would be extremely difficult. The innovative wireless communications system that we and ACOG developed is a big reason why the Centennial Olympic Games in Atlanta will showcase some of the world's finest athletes to the largest world audience in history.

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Performance mapping identifies simulcast problems

A signal analyzer with a built-in GPS receiver, a pager, a laptop computer and a communications test set gather data for simulcast performance maps that quantify a paging system's ability to deliver error-free data.

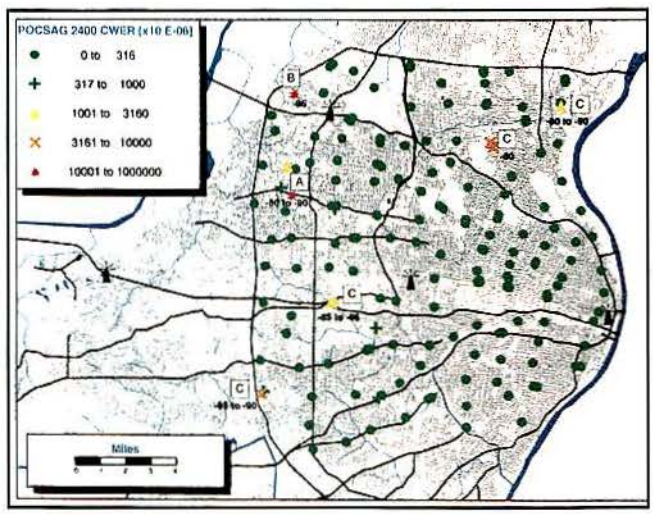

Figure 1. Codeword error map for POCSAG 2,400-baud data.

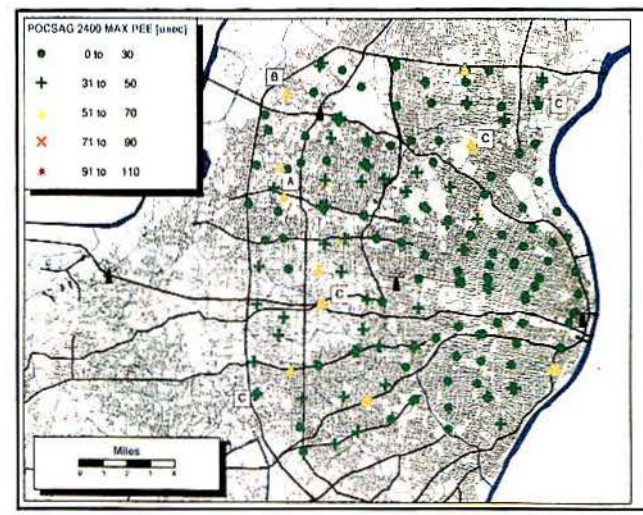

Figure 2. Maximum peak edge error map for POCSAG 2,400-baud data.

By Scott A. McFarland

Simulcast paging operators can now take advantage of a significant advancement in system test and measurement: signal performance mapping as seen by an actual pager. Signal performance maps can display the *bit error rate (BER), codeword error rate (CWER)* and two forms of *peak edge (PE) error* (errors in the location of bit cell edges) for the received paging signal throughout the geographic area measured.

The minimum measurement system consists of an Advanced Signal SignalPro signal analyzer and a modified Motorola ProEncore or NEC MessageMaker Exec pager. As this article was being written, we were aware of no other combinations of commercially available products that would allow this type of performance mapping to be conducted. The pager is modified to provide an output for the receiver's recovered audio signal. This signal is fed into the signal analyzer for decoding and signal analysis. The signal analyzer also logs the analysis results along with a physical location determined by an internal Global Positioning System (GPS) receiver.

A fundamental goal of our entire industry is to ensure that subscribers receive reliable, error-free data. Performance maps are a quantitative representation of a simulcast system's ability to deliver error-free data. The visual presentation of the bit error, codeword error and peak edge error on a map provide the operator with a clear indication of system coverage as seen by an actual pager.

The maps offer insight into the reasons for poor system performance. The maps also provide an ideal method for evaluating the effect of changes in operating characteristics or equipment in a simulcast system, such as deviation, deviation offsets and effective radiated power (ERP). How do you measure the effect of a change in a simulcast system offset plan? It is easy to evaluate if "before" and "after" performance maps are used.

The performance mapping method is an easy, cost-effective way to verify a system's message delivery capability. It can be used in conjunction with our channel loading product and with the channel's existing traffic.

Methodology

In the June 1995 issue, a test and measurement methodology was described that uses the signal analyzer, a modified pager and an RF communications test set.[1] The article stressed the importance of measuring a system's bit and codeword error performance as seen by an actual pager. It also recommended using an RF test set in areas with poor performance to record RF levels and viewing the recovered audio signal on an oscilloscope. It identified the biggest challenge in implementing Flex protocol as locating and analyzing areas of poor performance. The following

McFarland is chief technical officer at Advanced Signal, Quincy, IL. Advanced Signal manufactures the SignalPro data and signal analysis tool described in the article.

[1]"Data Analysis Aids Setup of Flex Paging Channels," June 1995, page 10.

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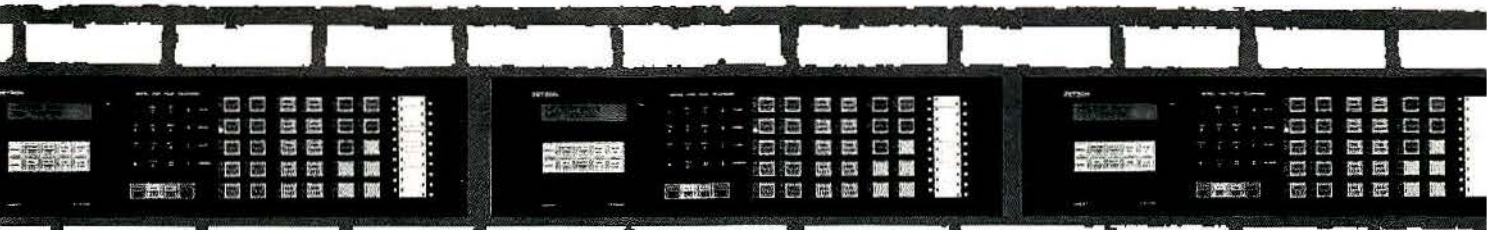

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Table 1—Logged Data for Maximum Peak Edge Error and Peak Edge 75th Percentile.

FORMAT	DATE	TIME	LATITUDE	LONGITUDE	BITS	BER	CWER	MAX PE	75 PE
F6400	10/15/95	08:43:49	38.62355000	−90.28628000	67,584	15	0	15	5
P2400	10/15/95	08:43:49	38.62355000	−90.28628000	116,416	0	0	20	10
F6400	10/15/95	08:52:53	38.60672000	−90.28794000	90,112	0	0	10	5
P2400	10/15/95	08:52:53	38.60672000	−90.28794000	90,304	0	0	10	0
F6400	10/15/95	09:02:47	38.59264000	−90.29469000	101,376	0	0	10	5
P2400	10/15/95	09:02:47	38.59264000	−90.29469000	109,344	0	0	10	5

information describes the data that are made available with that methodology.

Equipment used to collect the data included a SignalPro signal analyzer with a built-in GPS receiver, a modified Motorola ProEncore pager, a Hewlett-Packard Omnibook 600C (486DX2, 75MHz) laptop computer, an HP8920A RF communications test set with a battery pack and a portable power inverter. The inverter produces 115Vac from the car battery through a cigarette lighter adapter. The equipment was placed in a car with the pager clipped to the passenger-side sun visor, and a magnetic-mount GPS antenna was affixed to the roof. The inverter was used to power the signal analyzer and personal computer during the three days of data collection.

The mapping software used to create the accompanying figures was ATLAS GIS from Strategic Mapping. ATLAS GIS allows text files that identify data-collection points to be imported and overlaid on detailed street maps. A text file with the latitude and longitude for each transmitter site was created for display with the street maps to depict the expected coverage area. Next, the mapping software was used to produce regional maps within the coverage area. A 1-mile grid pattern was marked on the regional maps to identify potential measurement locations. The potential measurement points were adjusted to coincide with street intersections, and the cross-street names were obtained from the mapping software database. Identifying most of the points prior to the test minimized the time spent collecting data.

At the start of each day, the signal analyzer and console personal computer were switched on, and the internal GPS acquired a position fix. The position fix took about the same time that was required to travel to the first measurement location. Once at a measurement point, the signal analyzer uses GPS position data to determine that it is at a fixed location. The signal analyzer then clears all statistics and begins

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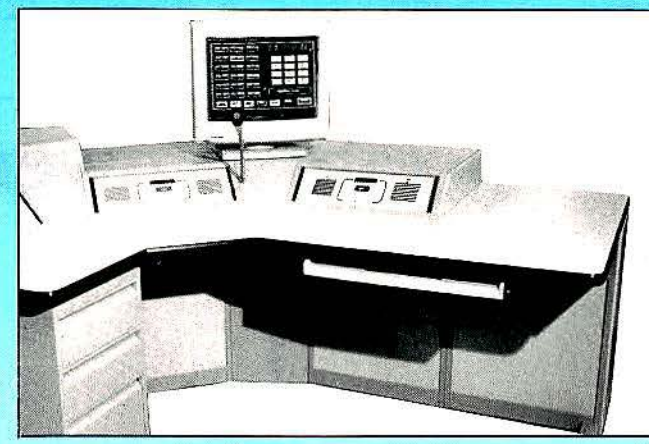

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analyzing paging data received from the pager. Performance data are accumulated on the live customer traffic already present on the channel. Communication with the office to request more test pages is not required. If customer traffic is not yet active, our channel loading product can be used to generate traffic for the channel. Bit error and codeword error rates for each format detected are accumulated over a four- to five-minute interval. This amount of time allows the signal analyzer to see a sufficient number of bits for a meaningful measurement.

Also, during the measurement interval, the worst-case *maximum peak edge error* and *peak edge 75th percentile* are logged. Peak edge error is a measure of the error seen in the location of bit edges for a given data rate. The max peak edge error value is the worst edge error that is measured, whereas the 75th percentile value indicates that 75% of the edges measured had an edge error at or less than the value displayed. An example of the logged data is shown in Table 1 on page 60.

The signal analyzer produces a series of tones to indicate that a data point has been obtained. When the analyzer is connected with a personal computer, data also are displayed on the channel metrics display window. Once the data point is obtained, the operator is free to drive to the next location and repeat the process. At the conclusion of every eighth data point, the signal analyzer logs the previous eight points to non-volatile memory. As many as 190 points can be logged in this manner. This method is useful if a console is not used in the collection process. At the end of the day, the signal analyzer can be instructed to download its analysis log to a console.

Periodically throughout the test interval, an HP8920A was used to obtain a measure of the RF field strength for the desired channel and the strength of adjacent channels. Also viewed was the recovered audio signal on the oscilloscope display of the HP8920A. Care was taken to make this observation for locations where the bit error was non-zero. Signal strength, and whether the signal exhibited fades or severe spikes on the data edges (which would indicate simulcast misalignment), were noted on the regional maps. This information also plays a role in the analysis of poor performance areas.

Displaying data on a map

The first step in displaying the performance data is to sort the data per format. This sorting is done with a utility provided with the signal analyzer console program. In this case, the sort utility produced two files, one containing the POCSAG 2,400-baud data and another containing the Flex 6,400-baud data. These files were then copied to the computer where the mapping program resided.

Table 2 on page 64 provides a sample of each sorted file. Next, the mapping program was started and the POCSAG 2,400-baud data file was opened. Within ATLAS GIS, the user selects columns in the data file to indicate latitude, longitude and the variable to be plotted. A theme is then specified that determines how the data is presented on the map. A "range plot" on the POCSAG 2,400-baud CWER column was selected. (See Figure 1 on page 58.) A range plot places a colored symbol at the specified coordinates based on the range in which the value in the CWER column falls. As an example, for each location where the CWER was less than 317×10^{-6} (317 per million), a green circle is placed.

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Table 2—Files Sorted by Format.

FORMAT	DATE	TIME	LATITUDE	LONGITUDE	BITS	BER	CWER	MAX PE	75 PE
----FILE 1----									
P2400	10/15/95	08:43:49	38.62355000	−90.28628000	116,416	0	0	20	10
P2400	10/15/95	08:52:53	38.60672000	−90.28794000	90,304	0	0	10	0
P2400	10/15/95	09:02:47	38.59264000	−90.29469000	109,344	0	0	10	5
P2400	10/15/95	09:10:47	38.57767000	−90.29420000	106,080	0	0	10	5
----FILE 2----									
F6400	10/15/95	08:43:49	38.62355000	−90.28628000	67,584	15	0	15	5
F6400	10/15/95	08:52:53	38.60672000	−90.28794000	90,112	0	0	10	5
F6400	10/15/95	09:02:47	38.59264000	−90.29469000	101,376	0	0	10	5
F6400	10/15/95	09:10:47	38.57767000	−90.29420000	123,904	0	0	20	10

A different map can be generated by selecting another variable or a new set of ranges.

Analyzing the performance maps

The performance maps presented here are for a 900MHz system operating in the St. Louis metropolitan area. Conditions in St. Louis are generally good for successful message delivery. The transmitters for this system are on building tops about 100 feet high, except for the downtown site, which is on a taller building. The use of any high-gain or pattern-altering antennas is unknown. The terrain is generally flat with some hills and valleys about 100 feet above or below the average elevation. The following is a brief review of the four factors affecting performance in this system.

▶ *RF signal fades or low signal level* — RF signals fade because of multipath and the characteristics of narrowband FM noise. Fading conditions constantly change with time. The depth of a given fade generally is modeled as a random variable with a Rayleigh or Rician probability density function. Fades of 15dB or more occur in most simulcast systems. Consistently low signal levels exist primarily because of shading from the terrain or other large obstructions.

▶ *Simulcast misalignment* — Simulcasting of multiple RF signals occurs when their RF levels (as seen by the receiver) are within roughly 10dB of each other. Decoders of simulcast signals generally can tolerate a misalignment between the signals of one-fourth of the bit time. For a 2,400-baud signal, this interval is 104 microseconds,

end for a 3,200-baud signal, the interval is 78 microseconds. Also consider the affect of the RF exciter's rise time on the tolerable misalignment. For a 3,200-baud signal, an exciter rise time of 88 microseconds consumes 28% of the bit time. If this interval is taken into account, the signal spends only 225 microseconds at its desired deviation. One-fourth of this time is only 56 microseconds. Depending on which value you subscribe to, the tolerable propagation difference between two signals, simulcast at 3,200 baud, is 10 to 14 miles.

▶ *Combinations of fades and simulcast misalignment* — Many consider simulcasting to occur only at locations roughly equidistant from two or more transmitters. Consider the case when the primary (or nearest) signal fades or is otherwise blocked by a hill or obstruction. If secondary (or more distant) transmitters are capable of supplying a signal at this location within 10dB to 15dB of the primary (prior to a fade), then some percentage of fades will result in a simulcast condition between the signals. If the propagation difference for the distant transmitters approaches a quarter of a bit time, simulcast misalignment situations will exist. This condition can, and does, exist in many simulcast systems.

▶ *Interference* — When a signal level in a neighboring channel is significantly higher than the desired signal, energy from the neighboring signal may not be sufficiently rejected by the IF filters within the receiver. The remaining energy disrupts the decoder's ability to accurately decode the data.

The ranges selected for each of the maps indicate where excellent, marginal and poor message delivery performance can be expected. Green symbols indicate excellent performance, yellow and orange symbols indicate marginal performance, and red symbols indicate poor performance. The codeword error rate map is used for the following discussion because it most closely represents the probability of a missed or garbled message. Codeword error rate represents the proportion of codewords received that contained three or more bit errors, rendering the codeword uncorrectable. Codeword error rates take into account the bit error correction embedded in the paging format. The peak edge error ranges were selected to place a red symbol where peak edge error reached 25% of the bit time. The green, yellow, and orange symbols subdivide the remaining error range. The RF levels measured by the RF test set were added manually to the maps.

Note that several measurements were taken at some locations. This was done because the pager antenna can be highly directional. If the pager's orientation had an effect on the bit error rate, additional readings were taken at different orientations. This is why some locations have more than one colored symbol on the error maps.

The POCSAG 2,400-baud codeword error rate map identifies six poor performance areas. (See Figure 1.) Area A is subject to interference from a channel 100kHz away. The interferer is 30dB to 40dB greater than the desired signal. The interference was so strong that when the channel was keyed, its signal was audible along with the desired signal. Area B is adversely affected by a consistently low signal level. A −95dBm RF level is too low for the pager and the signal analyzer to decode POCSAG 2,400-baud reliably. "C" identifies an area that is subject to 10dB–15dB RF fades. Because the signal is weak to begin with in these areas, fades

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of 10dB–15dB are enough to drop the signal level too low for reliable decoding. Any visible, or audible, evidence of simulcast misalignment in these areas was not noticed.

The data displayed on the POCSAG 2,400-baud peak edge error map for each Area C show errors of 70µsec or less. (See Figure 2 on page 58.) This supports the conclusion that simulcast misalignment did *not* play an important role in degrading the performance at 2,400 baud.

The Flex 6,400-baud codeword error rate and peak edge error maps identify additional marginal or poor performance areas for the higher data rate format. (See Figures 3 and 4 on page 68.) To minimize clutter, the Areas A, B and C from the POCSAG 2,400-baud maps are not repeated on the Flex maps. These areas perform poorly for Flex 6,400-baud for the same reasons as POCSAG 2,400-baud. On the Flex maps, there are two additional A areas where an interfering signal was able to affect Flex decoding. The interferer(s) were 75kHz–100kHz away at a level 25dB above the desired channel. Errors were indicated on the front panel of the signal analyzer when the other channels were keyed. There is one additional Area B where the RF level was –93dBm. This level is too low for the pager and the signal analyzer to decode Flex protocol reliably. Five additional areas are marked solely with a C. These areas are affected by RF fades that dropped the signal level below that for which Flex protocol can be reliably decoded. A "D" identifies those areas where an RF fade resulted in the simulcast of misaligned signals. As the primary signal fades, it simulcasts with the signals from more distant transmitters. For Flex 6,400-baud, the distant transmitters are far enough away to result in errors due to misalignment.

The Flex 6,400-baud peak edge error map also supports this conclusion with measured peak edge error measurements from 30µsec to 70µsec in those areas. (See Figure 4.) There are two areas marked with a C and D. These areas have a slightly lower peak edge error reading, but the combination of a faded signal and misalignment work together to degrade the performance at these locations.

Both the POCSAG and Flex peak edge 75th percentile maps were all within green limits. This indicates that there are no consistent simulcast misalignment areas, but rather conditions that produce a brief fade of the primary signal, which now simulcasts with a signal from a distant site. This condition, however, does not strongly affect the 2,400-baud data because the distant sites in this system are well within the 21-mile limit for propagation differences. The 3,200-baud data are altered because the sites are a net distance of 10–14 miles away from the affected areas. The signal strength data in Figure 2 bring to light the fact that signal strength is not always a clear indicator of system performance at higher baud rates.

Conclusion

Performance maps provide a visual representation of system capability over a geographic area. Error rates are obtained using customer traffic. The operator does not have to watch for test pages that only account for a small portion of the channel's transmission time. Data are acquired quickly and accurately using the signal analyzer with a modified pager. The RF test set (in this case, the HP8920A) provides additional data that, when combined with the maps, give the operator

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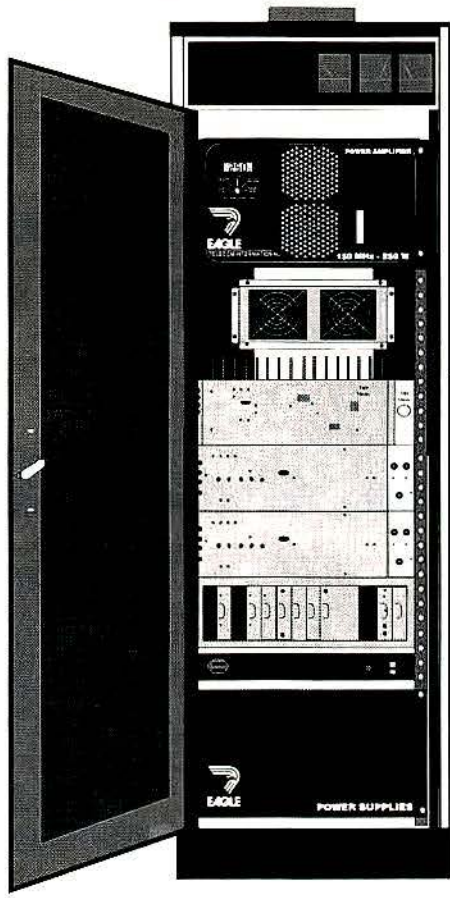

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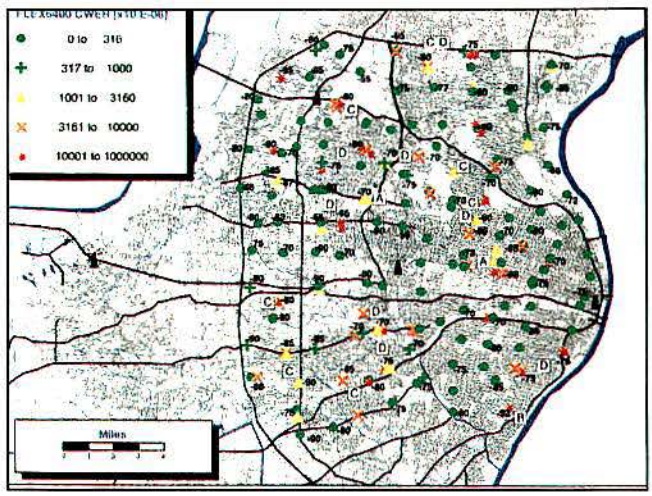

Figure 3. Codeword error map for Flex 6,400-baud data.

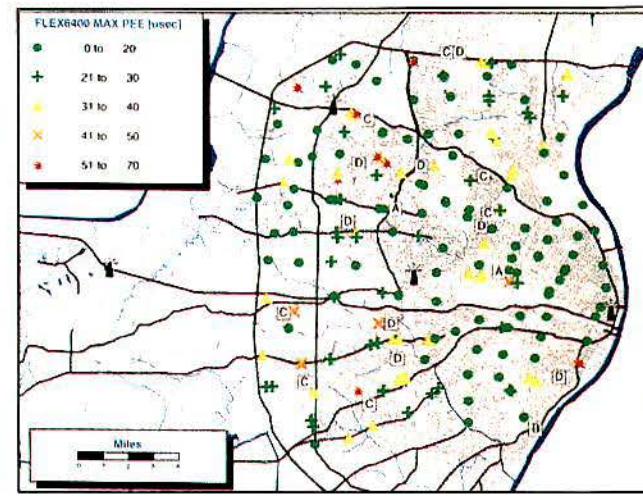

Figure 4. Maximum peak edge error map for Flex 6,400-baud data.

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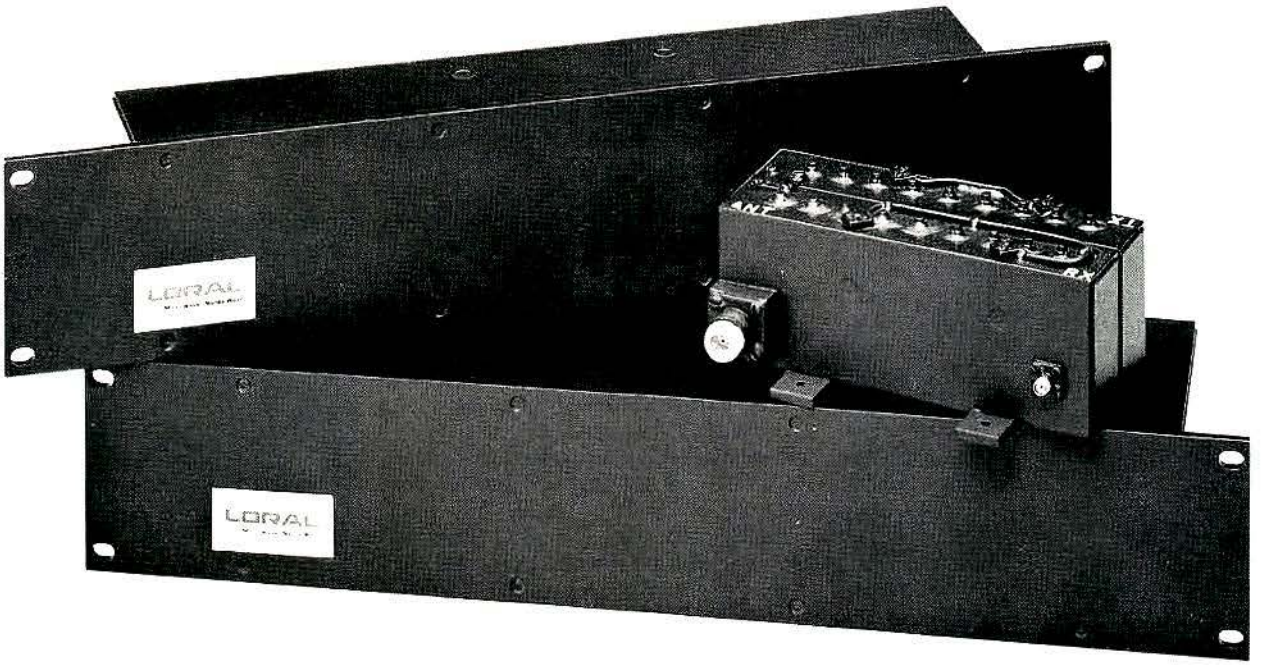

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LORAL

Microwave-Narda West

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(continued from page 8)

only adds up to 5.71V—nowhere close to the 12V supply voltage. What happened to the other volts?

To further confuse the issue, the multimeter connected across R_1 was switched from the 50V scale down to the 10V scale. (See Figure 4 on page 8.) Now the voltage reading becomes 1.71V. What's going on? Don't throw out the multimeter just yet! Let's explore the situation to find out what is really happening here.

Remember the ohms/volt sensitivity specification? That is the basis for solving this mystery. Back in Figure 2 where the first voltage measurement was made, the multimeter was switched to the 10V scale. The dc sensitivity of this particular multimeter is 20,000 ohms/volt. Thus, on the 10V scale the instrument presents a shunt impedance of 20,000 × 10 = 200,000Ω. Now, if we substitute a 200,000Ω resistor for the multimeter, we can better understand what is happening to our circuit. (See Figure 5 on page 8.) Here the circuit is redrawn with a 200K resistor representing the multimeter shunt impedance. The two resistors in parallel can be reduced to a single 166.667K resistor as shown in Figure 6 on page 8.

The voltage drop across the 166.667K resistor should be equal to:

$$\frac{R_2}{R_1 + R_2} \times E_S = \frac{0.166667}{1 + 0.166667} \times 12$$

$$= 0.14286 \times 12 = 1.71\text{V}$$

Thus, the reason for measuring 1.71V across R_2 is the shunting effect of the input impedance of the multimeter. A multimeter with lower sensitivity (lower ohms/volt) would produce even worse readings. See Figure 7 top, right where a "bargain" 2,000 ohms/volt meter is used to measure the voltage across R_2. With the meter switched to the 10V range, the impedance of the multimeter is 20,000Ω. The meter reading is only 231mV. This is the actual voltage across the resistor when the meter is connected, but when the meter is removed, the voltage across R_2 goes back up to 6V. If the original multimeter with 20,000 ohms/volt sensitivity were switched to the 2.5V range and connected across R_2, the meter would read 545mV as shown in Figure 8 center, right.

From this we can reason that to determine whether the multimeter is causing significant loading of the circuit under test, simply increase the range setting on the multimeter. If the voltmeter reading increases substantially, then the meter is causing serious loading of the circuit. To minimize loading of the circuit under test, the multimeter should be switched to the highest useable range. If the multimeter input impedance is 10 times greater than the resistance of the circuit being tested, then the error caused by loading will be extremely small and

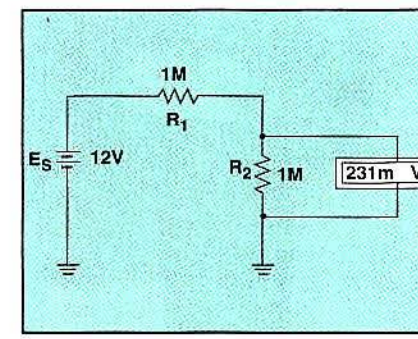

Figure 7. The voltmeter here simulates a multimeter with a "whopping" 2,000 ohms/volt sensitivity. It is switched to the 10V range and thus exhibits a shunt impedance of 20,000Ω.

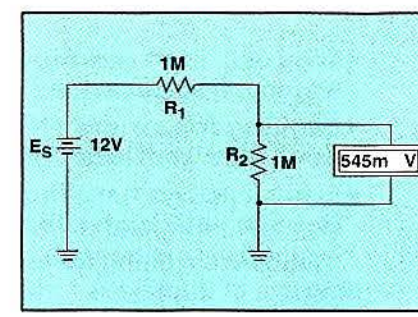

Figure 8. The voltmeter here simulates a multimeter with a sensitivity of 20,000 ohms/volt and set to the 2.5V range. On this range the meter has a shunting effect of 50,000Ω.

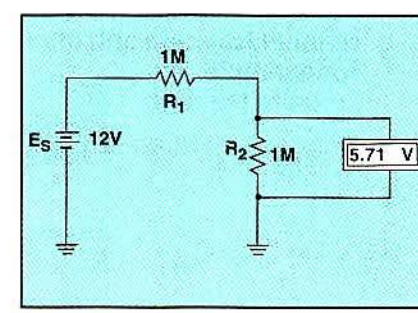

Figure 9. The voltmeter here simulates a digital multimeter with an input impedance of 10M on all ranges.

(continued on page 74)

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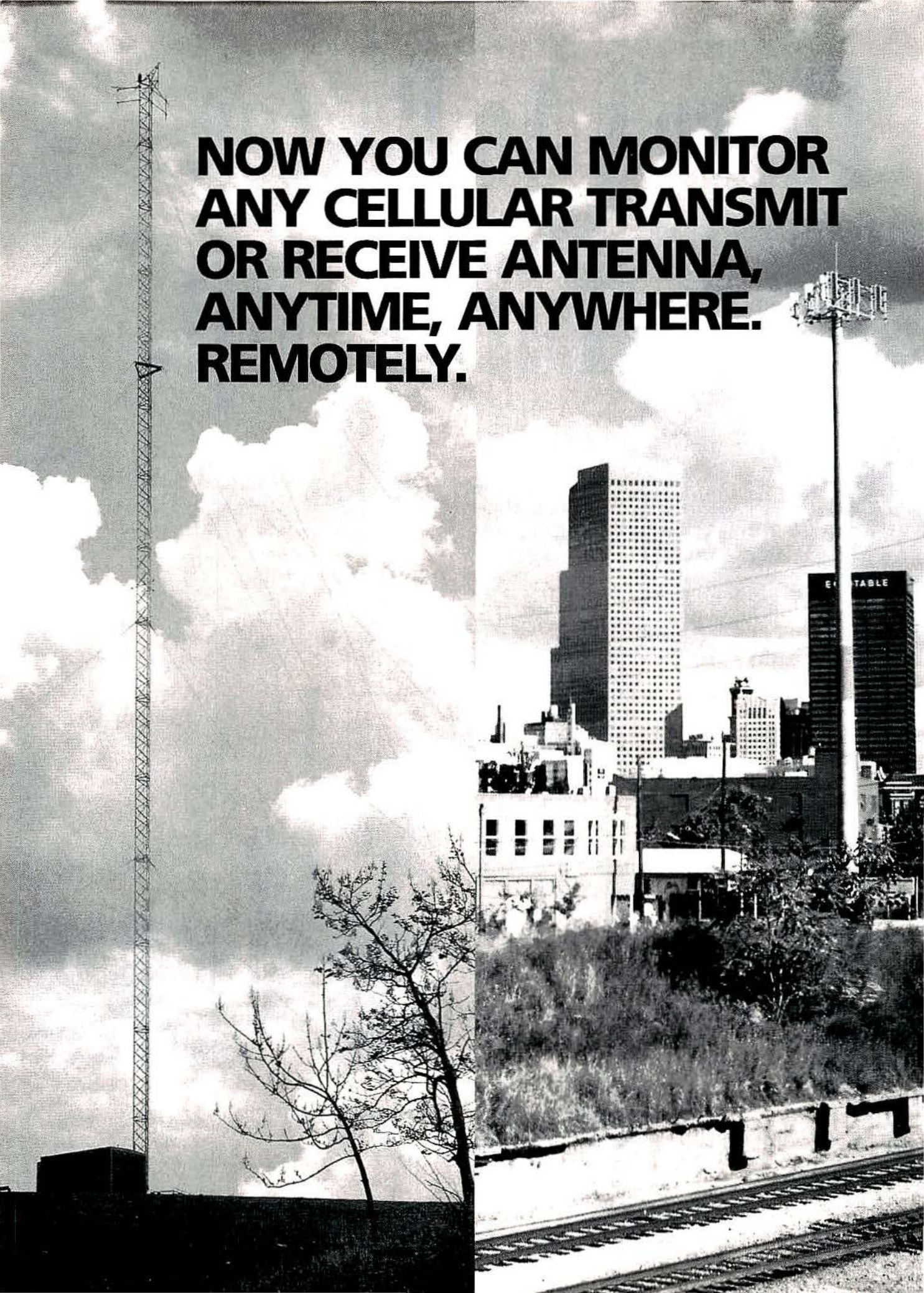
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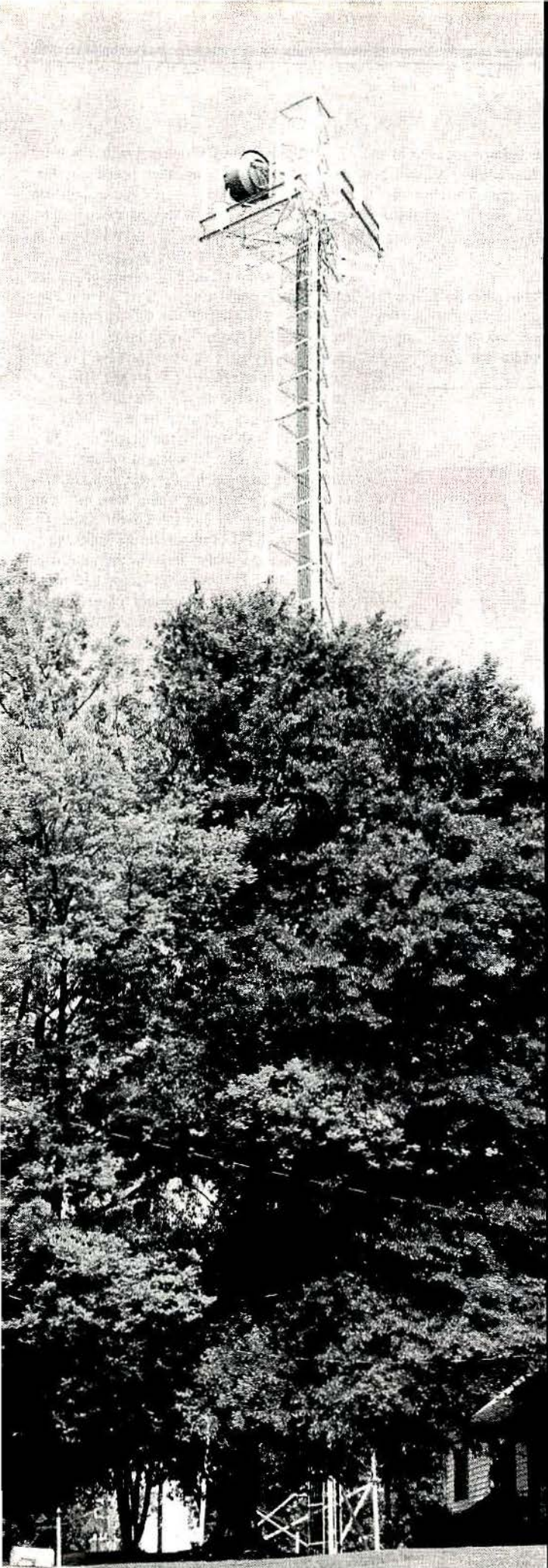

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LORAL

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(continued from page 70)

generally acceptable for all but the most critical applications.

▶ *Digital multimeters* — Digital multimeters are popular, even among the "old salts." The input impedance of these instruments is generally around 10M and doesn't vary with the range setting. Figure 9 on page 70 shows such an instrument connected to the same circuit we have been discussing. Here, the voltage measurement is 5.71V. Because the voltage should be 6V, the error is less than 5%. For most servicing applications, this is well within the acceptable limits.

Other instruments

Multimeters are not the only instruments that cause loading errors. Almost any instrument connected to high-impedance circuits can produce loading errors. Let's look at the RF voltmeter that is used to measure RF voltages on tuned circuits.

▶ *RF voltmeter* — In Figure 10A on page 76 is an RF resonant circuit. The resonant frequency of the tuned circuit is about 160MHz. (See the graph in Figure 11 on page 76.) The RF voltmeter has an impedance consisting of 2pF across a resistance of 100K. If the RF voltmeter is connected to point 2 at Figure 10B, the probe loading is represented by the red capacitor and resistor. With the RF voltmeter connected to the circuit, the resonant frequency changes from 160MHz to 145MHz as shown by the graph in Figure 12 on page 78. To determine just how much loading error your RF voltmeter is causing to the circuit under test, you can use the setup in Figure 13 on page 78. Here, two RF voltmeters are used. One is connected to a point early in the amplifier chain, and the other is connected to a point at the end of the amplifier chain. First, connect RF voltmeter No. 2 to the circuit. Then, while observing the reading on voltmeter No. 2, touch the probe of RF voltmeter No. 1 to the circuit. If the reading on voltmeter No. 2 changes little, then the loading of voltmeter No. 1 is insignificant. Make sure that the stages between the two voltmeters are not *limiter* stages! If limiter stages separate the voltmeters, then the reading on voltmeter No. 2 may not change much even if voltmeter No. 1 is causing serious loading on the circuit.

Multimeters are not the only instruments that cause loading errors. Almost any instrument connected to high-impedance circuits can produce loading errors.

Summary

The point of all this is to increase your awareness of instrument loading effects. Don't let the loading errors set you on a wild goose chase! In critical, high-impedance circuits, use instruments that cause minimal disturbance to the circuit under test. Sometimes compensations for minor RF voltmeter detuning or loading can be made by temporarily retuning the circuit to which the meter is connected to "peak" the meter reading. Then, once the meter is

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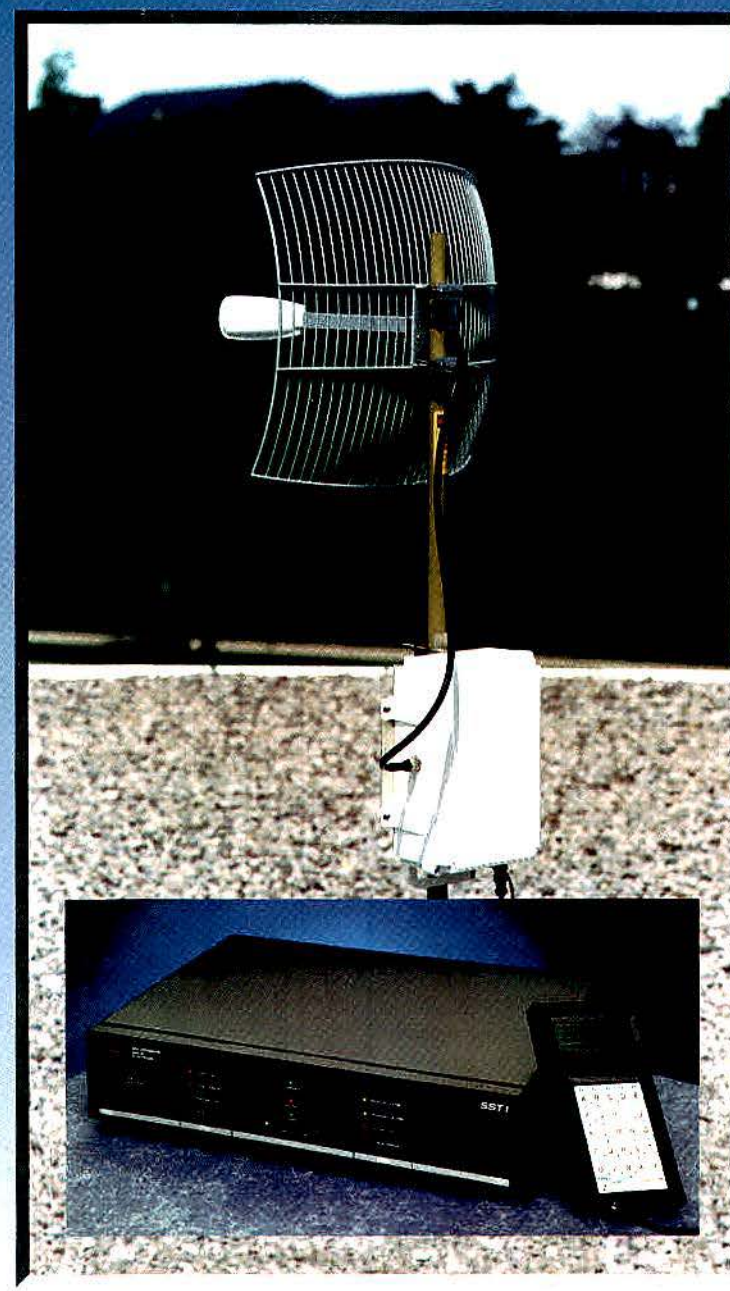

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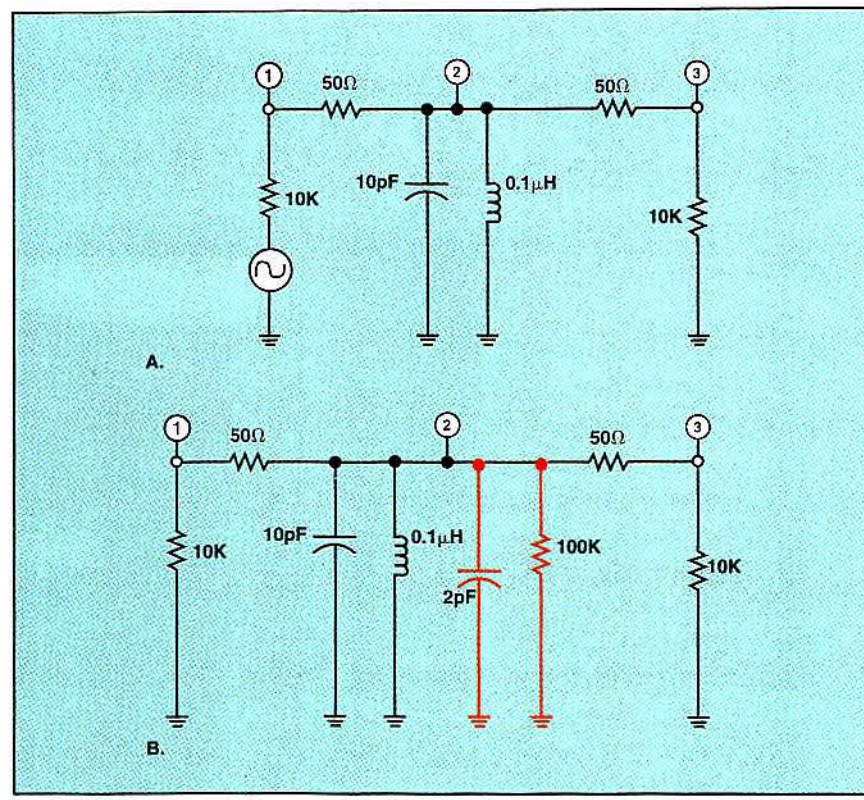

Figure 10. The schematic at A represents a resonant circuit tuned to about 160MHz. At B an RF voltmeter has been connected to test point 2, and the loading effect is represented by the red capacitor and resistor.

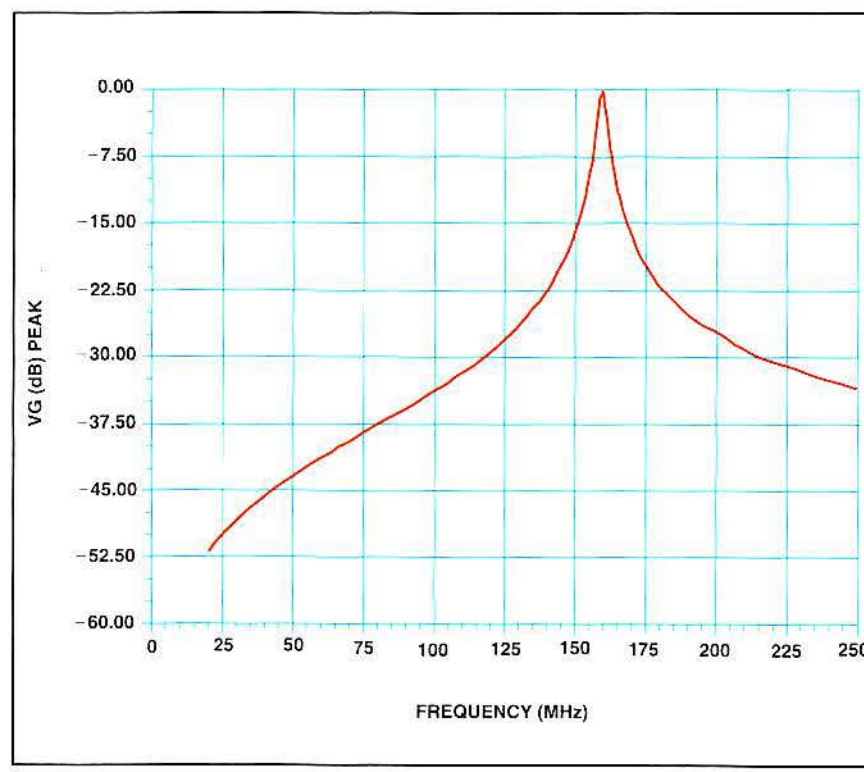

Figure 11. The response of the circuit of Figure 10A is shown here. This is without the RF voltmeter connected. (Compact Software—ARRL Radio Designer 1.5)

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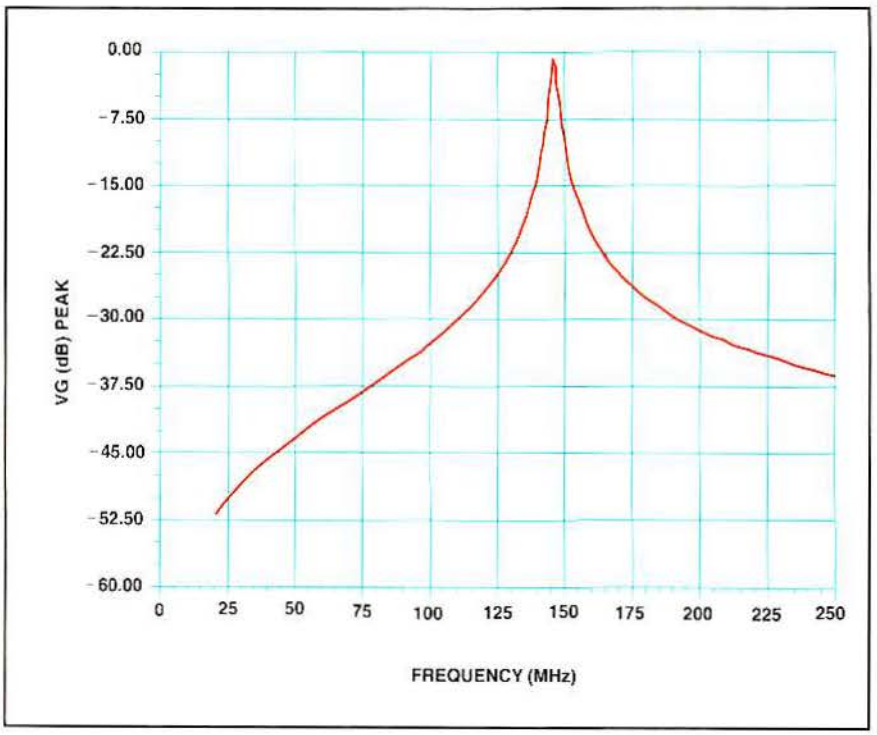

Figure 12. The response of the circuit of Figure 10B (RF voltmeter connected) is shown here. (Compact Software—ARRL Radio Designer 1.5)

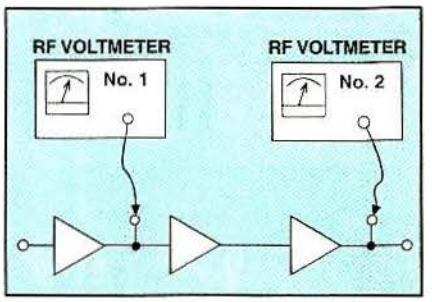

Figure 13. To determine if serious loading is being caused by an RF voltmeter, this setup can be used. First, connect voltmeter No. 2 as shown. Then connect voltmeter No. 1 and note any change in the reading on voltmeter No. 2. If there is little or no change in the reading of voltmeter No. 2, then voltmeter No. 1 is not causing any significant loading or detuning of the circuit under test. Make sure there are no limiters between the two voltmeters or the result could be invalid.

removed, the tuning inductor or capacitor is returned to the original setting.

It is just as important (or more so) to know the limitations of your equipment as it is to know its capabilities. The more you know about your test equipment, the less likely you are to go wild-goose chasing!

'Til next time...*stay tuned!*

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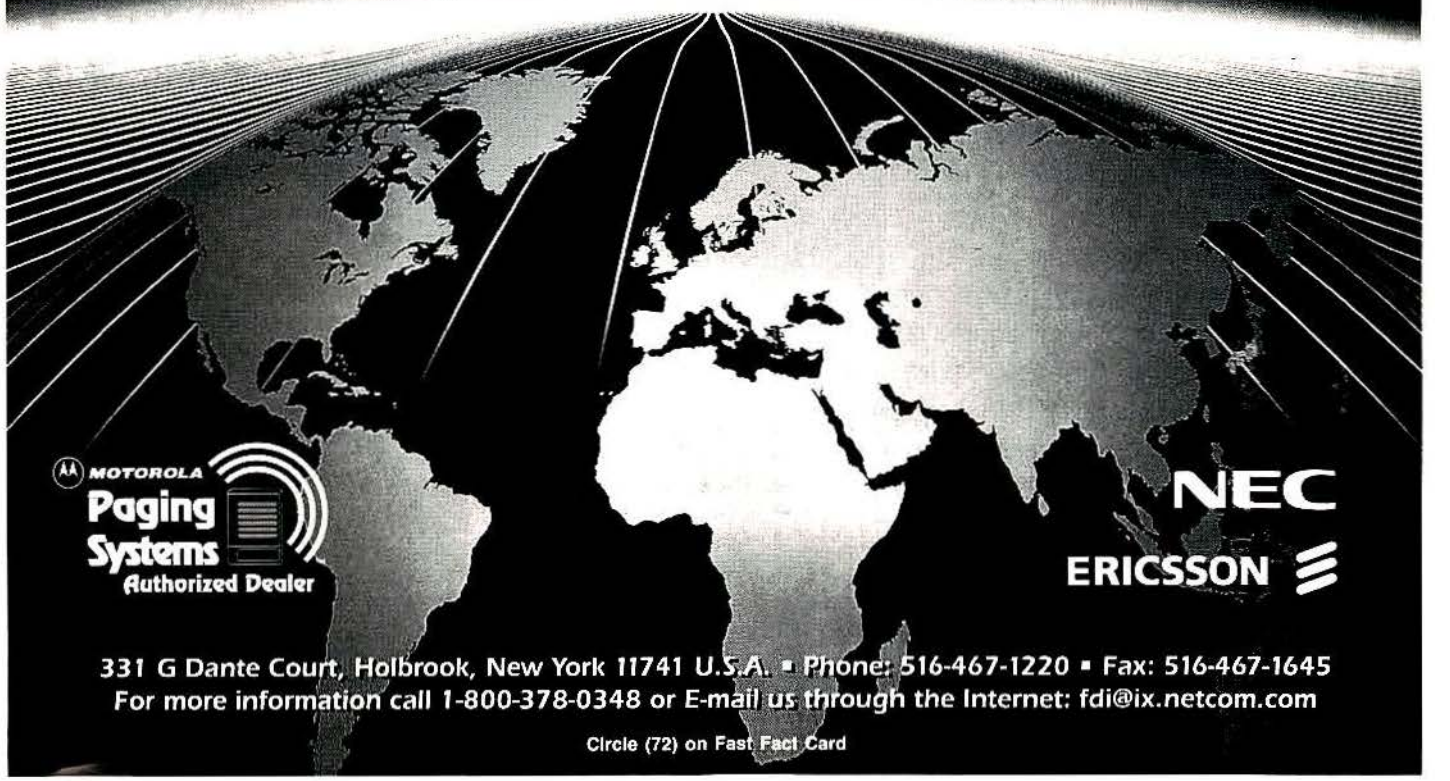

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Circle (72) on Fast Fact Card

The feds' new credit union

By Robert H. Schwaninger Jr.

In case you missed the news, the Congress of the United States adopted an interesting piece of legislation as part of the Telecommunications Act of 1996, which is intended to provide benefits for small business. Within the Act, Congress set up something called the Telecommunications Development Fund, or if you like, the Local Operator's Credit Union.

The fund will be created by interest on upfront payments, made by the FCC auction participants, which is earned by having those payments sitting in an interest-bearing bank account. If it uses my bank, that means that the fund will get the 0.0000314% uncompounded interest rate I get (providing it's willing to pony up the ten bucks for personalized checks). I guess my first question is, who gets the free toaster?

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.

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For those of you who haven't yet discovered the peccant aftertaste of a valium-and-scotch shake, following a day of fun participating in an FCC auction, you probably don't know about upfront payments. That's the amount of money the FCC wants you to pay upfront to show that you really want to play in an auction. Think of it as an ante. Toss a few chips into the federal pot and you're in the game. Anyway, the interest on the ante makes up the fund.

In theory

The fund board is supposed to use money created by interest on this ante to promote small business in ways such as financing small businesses' use of emerging technology, making loans and giving quarters to needy local operators who are willing to wash the board members' windshields while they're waiting for the light to change. So, in theory, this idea is pretty great.

Because the biggest upfront payments come from the fattest cats in the industry, this fund would provide for a kind of revenue sharing. If word gets out, the blueprint for the Telecommunications Development Fund might be used to solve the next baseball labor dispute. In the meantime, it might just do some real good.

If you read this column regularly (It can't be blocked by the "V" chip), you know that I have shown some tendencies toward skepticism. To say that I'm jaded is to barely scratch the surface of my paranoia. But, in all fairness, I believe that the fund has a chance to be something really worthwhile.

The fund board is supposed to use money created by interest on this ante to promote small business... Since the biggest upfront payments come from the fattest cats in the industry, this fund would provide for a kind of revenue sharing.

The fund could be used to capitalize ventures that otherwise would be unable to come to market, due to the limited resources of the operators. It could serve as a way of assuring that legitimate local operators don't run short in their race to compete with larger competitors. It might provide ways for small operators to provide equipment necessary for disabled Americans to access small, local systems. Or, it could finance new forms of resale, interconnection and other functions which would be tailored to serve the needs of the industry's smallest players.

But for every benefit that the fund might bring, there are hurdles standing in its path. First, the language of the Telecommunications Act states that every business with less than $50 million in average revenues is considered a "small business." Although I haven't checked his latest IRS 1040EZ Form, that might mean that Donald Trump is eligible for a loan from the fund.

Second, the board members are to be selected by that champion of small telecommunications businesses, Chairman Reed E. Hundt. Given his demonstrated

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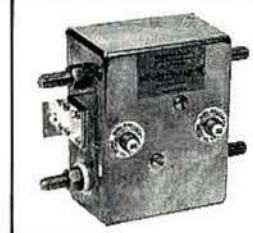
UNI-KIT COAX CABLE GROUNDING

DATA/PHONE PUNCH DOWN BLOCK



SOLAR/BATTERY

PHONE LINE/LAN/T-1

POWER PROTECTOR 120/240Vac,15-20A

1.2 TO 20GHz MICROWAVE & DOWNCONVERTERS

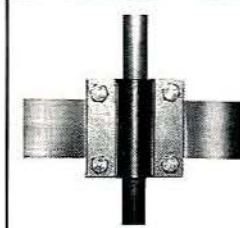
IN-LINE POWER MAINS

COAX PROTECTOR WITH SAMPLER PORT

SHUNT-TYPE POWER MAINS

CELLULAR PROTECTORS TO 980MHz

STRIKE COUNTERS TOWER/POWER/PHONE



GROUNDING COMPONENTS

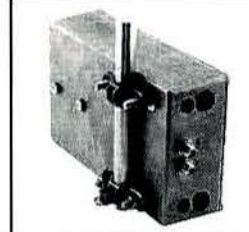
LAN/VIDEO

GLOBAL POSITIONING SYSTEM (GPS)

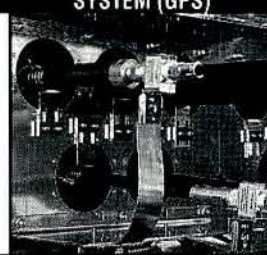
UHF COMBINERS

POWER SUPPLY PROTECTOR

COPPER CLEANING KIT (CCK)

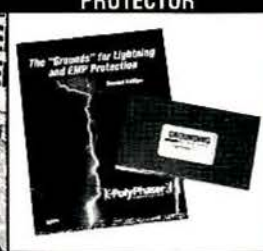


TVRO PROTECTOR LNB & MOTOR CONTROL



COAX ENTRANCE PANELS

CONSULTING



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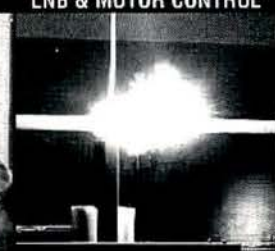

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Circle (76) on Fast Fact Card

compassion for small business (which can be found in his support for auctions at 800MHz, 900MHz, paging, and PCS), this is akin to having Attila the Hun create the first Welcome Wagon committee. The spoils systems is really living up to its name.

Finally, there is Chairman Hundt's recent appointment of the Interim Chairman of the Board of the all new and really exciting Telecommunications Development Fund, Mr. Solomon D. Trujillo. Let me be one of the first people to congratulate Mr. Trujillo on his appointment. I wish him well.

You note that I refer to the new interim fund board chairman as "Mr." I think anyone who reaches the exalted position of president and chief executive officer of US West Communications Group deserves our respect. I'm certain that his experience with the financial problems suffered by US West prepared him well for his newly appointed position.

Mr. Trujillo also brings a wealth of experience in serving small business. His biography includes his former position as vice president and general manager of US West Communications' Small Business Group, "serving nearly 800,000 small business customers in 14 states." Those 800,000 windowed envelopes sent each month by his group are compelling evidence of his willingness to address the problems suffered by local operators.

All teasing aside, Mr. Trujillo might do a fine job. I hope so. I believe the fund can do fine things if it focuses on truly providing necessary relief for small businesses that are falling behind in the gadget race. The question remains, however, as to who will serve on the board. Who will assure that it is *real* small operators, who have suffered financially during these changing times, that get a little help in making the transition to newer technologies? Many people supported *my* nomination, including (get this) a real U.S. senator. To those people who supported my nomination, I wish to give you my sincere thanks. There's no reason you can't have a sense of humor *and* a sense of purpose.

If selected by Chairman Hundt, I will first pick up my jaw before someone steps on it, then I will do my best to live up to the industry's expectations. If I am not selected, I will wish the new board well in its difficult task ahead. The fund isn't very large right now, but the need is great.

The fund can do fine things if it focuses on truly providing necessary relief for small businesses that are falling behind in the gadget race... The question remains, who will assure that it is real *small operators that get a little help in making the transition to newer technologies?*

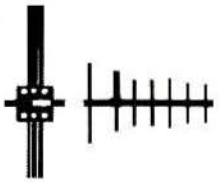
The Industry's

10 MOST WANTED

Considered Armed & Dangerously Affordable

Industry Top Ten Product

ANT940Y10-WR, also known as Yagi Antenna. born 6-24-74; 2.5 lbs; 24" x 9"; Known associates: likes to hang out in dingy, dismal areas. hvy bld; blk TXYLAN coated. Known to violently resist corrosive gases, ultraviolet radiation, salt spray and acid rain. Wanted for directional control.



PRINTS AVAILABLE

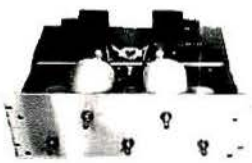
Industry Top Ten Product

TS4680, also known as Cross Band Coupler. born 2-10-86; size 6.6 x 1.5 x 0"; 1 lb; hvy const; 400 watts; blue finish; tower mountable. Wanted by tower operators for multiple transmissions of 450-860 equipment.

PRINTS AVAILABLE

Industry Top Ten Product

TC860, also known as Cellco Ceramic Trunking Combiner. born 5-25-91; size 7x19x14"; 36 lbs; rugged bld; 125 watts, alum finish. Wanted by SMR operators who want only the best.



PRINTS AVAILABLE

Industry Top Ten Product

ANT450D3, also known as Dipole Array Antenna. born 9-14-58; known associates: other antennas in other freq bands and gain. hvy bld; blk TXYLAN coated. Known to violently resist corrosive gases, ultraviolet radiation, salt spray and acid rain. Wanted by tower operators with the worst possible problems.

PRINTS AVAILABLE

Industry Top Ten Product

Model 44AP, also known as the Broadband RF Wattmeter. born 6-11-78; weight 4 lbs; rugged bld; 500 watts; gray comp; operates alone, no known associates; distinguishing marks: leather band on top, sample port right side. No known enemies, has been spotted worldwide.

R. Middle

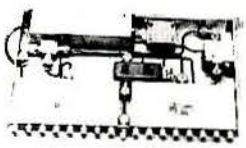
Industry Top Ten Product

PMU1C1S, also known as Power Monitor Unit. born 4-23-95; sml bld; blk, red eyes glow in dark. Wanted for monitoring ant VSWR and TX power. Notorious for working multiple freq in all bands. Known associates RS232 and RS485.

R. Index

Industry Top Ten Product

TWR816-860-1RTT, also known as Compact Receiver Panel. born 8-14-93; exceptional small build, likes to associate with multiple frequencies. Quiet 2.5 dB noise; modular; has been known to redundantly switch to 2nd channel if injured; likes living in harsh locations. Wanted for resisting interfering signals.

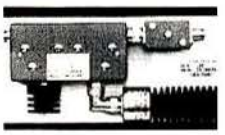


PRINTS AVAILABLE

Industry Top Ten Product

TS450PB1, also known as IM Suppression Panel. born 7-12-75; rugged bld; black & blue marks on body; 5 lbs; 19"x5.25"; 450 w[illegible] dB; wanted by tr[illegible] for killing intermod[illegible]on; likes isolati[illegible] Reward is offered for protectionism.

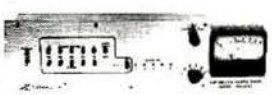
IM CAPTURED



PRINTS AVAILABLE

Industry Top Ten Product

PM5C1S, also known as Automatic Alarm Panel. born 2-23-81; brushed alum; 1.4 lbs; 19"x3.5"; Known associates: likes to snitch on bad trans & ant; needs to be placed inline; violently resists high VSWR; likes power. Do not approach, will call you.



PRINTS AVAILABLE

Industry Top Ten Product

TATC8944, also known as Cellular Auto Tune Ceramic Combiner. born 4-1-92; size 10.25W x 10.75H x 12.75"; 36 lbs; heavy bld; black finish; easy to install. Wanted by Cellular operators for retrofit or new installations, both in USA and foreign countries.

L. Thumb

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Circle (78) on Fast Fact Card

Securicor is new destination for Midland International

A few months ago, plans were announced to merge Midland International, Kansas City, MO, with Intek Diversified, Torrance, CA, and Midland Systems, Pickering, Ontario, Canada. Midland International, a manufacturing company, and Midland Systems, a systems integrator, are wholly owned subsidiaries of Simmonds Capital, Willowdale, Ontario, Canada, and Simmonds owns a controlling interest in Intek.

On March 8, together with Securicor Group, Surrey, UK, Simmonds announced a revised plan to combine Intek's Roamer One airtime services business with Midland International's U.S. land mobile radio business and with certain manufacturing operations of a Securicor subsidiary, Securicor Radiocoms. Under the plan, Intek will acquire Securicor Radiocoms, including its linear modulation radio technology, a manufacturing facility in Bath, UK, a network of UK dealers and resellers, a UK specialized mobile radio (SMR) network, a systems integration business and all of the convertible preferred E.F. Johnson stock that Securicor owns.

Simmonds would retain Midland International operations outside the United States and would retain Midland Systems, which operates as a systems integrator for wide-area networks. Brian Faughnan, a Simmonds spokesman, explained that in the United States, the systems integration business will be carried on through Intek after the merger. The Midland Systems headquarters will remain in Canada, and the company will continue to offer worldwide systems integration services.

With Intek acquiring Securicor Radiocoms in exchange for stock, Securicor Group will gain control of Intek and, through it, Midland International. Intek then is expected to raise funds to continue building the Roamer One SMR network and to use as working capital.

Intek stock trades on the NASDAQ exchange under the symbol IDCC. The Roamer One 220MHz radio network is its principal business.

Securicor Group stock trades on the London exchange under the symbols Securicor, Securicor A and Security services. Securicor Group's businesses include security services, parcel and freight distribution and fixed and mobile communications, and the company owns 40% of the UK cellular system operator Cellnet.

Simmonds stock trades on the Toronto exchange under the symbol SMM. The company manufactures, distributes and integrates communications equipment and systems and produces and distributes electronic components.

L.A. Cellular deploys "Spy" technology to cut fraud

Technology originally developed for signal intelligence applications is now being used in Southern California to help eradicate cellular pirating with Los Angeles Cellular Telephone Company's deployment of a state-of-the-art cellular fraud prevention system called PhonePrint.

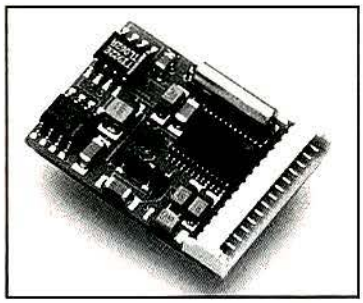
Developed by Corsair Communications, Palo Alto, CA, PhonePrint uses defense conversion technology to spot a clone cellular phone call within a fraction of a second and disconnect the call. The technology is expected to reduce fraud by at least 75%, based in part on a test on L.A. Cellular's system.

Alarm annunciator includes RF power sensor inputs for remote sites

Barnett Engineering has added the ProTalk RFX to its line of voice alarm annunciators. The low power monitor with RF power sensor inputs is designed for use at remote radio sites. The unit operates over a temperature range of −40°C to +60°C with an average current drain of only 5.1mA. Monitoring analog values and digital status points, the monitor can generate as many as 40 alarm messages. Inputs include VSWR, forward power or reverse power for as many as eight radios; voltage and current for both battery and charger in standby and transmit conditions; temperature; and user-programmable alarms. Alarm messages are relayed to a radio or pager in a toll-quality voice. Two output relays can be operated remotely at the site by DTMF codes. The unit likewise can be acknowledged or interrogated.

Circle (417) on Fast Fact Card

Scrambler uses voice inversion for two-way radio systems security



The model NC802 micro-miniature voice inversion scrambler provides intermediate level security for two-way radio voice communication systems. The unit from **Norcomm** features simultaneous scrambling and descrambling, selectable scrambled or clear mode, remote selection of one of eight commonly used inversion frequencies and low-current operation. Roughly one-inch square, the unit is ideal for application in portables.

Circle (418) on Fast Fact Card

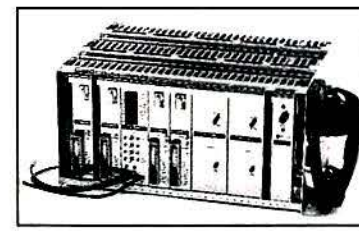
Spectrum analyzers provide high accuracy for digital mobile radio

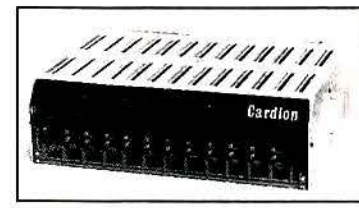
The MS2651A and MS2661A spectrum analyzers from **Anritsu Wiltron** for 9kHz to 3GHz are designed for the development, manufacture, installation and maintenance of digital mobile radio and general communications systems. Weighing less than 23 pounds, the units feature menu operation, highly stable frequency measurements, low distortion characteristics and a span accuracy of 2.5% with 501 sampling points. An auto-calibration function provides an overall level accuracy of ±1.1dB. A high-speed time domain sweep option is available, designed to measure time-bursted parameters of digitally modulated signals.

Circle (419) on Fast Fact Card

New products

Radio, multiplexer extend point-to-point coverage





The Cardion Communications division of **Nutel Electronics** manufactures point-to-point FM analog microwave radios and frequency division voice multiplex units. The model 8000 Comm-Pak radio (top), operating from 790MHz to 2,500MHz, can extend as many as 36 individual phone lines when used in conjunction with the 9500 multiplex and associated termination sets. The Skytrax 9500 DTL multiplex (bottom) is a synthesized, field-programmable unit with 9.6kbps/14.4kbps data capability. CCITT-compatible, the Skytrax can receive and transmit data or voice and has a 1- to 634-channel capability.

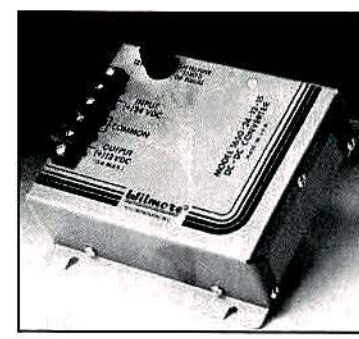
Circle (420) on Fast Fact Card

Low-loss assemblies make 7/16 DIN connections

Cable assemblies with 7/16 DIN connections are available from **Times Microwave Systems**. Designed for indoor or outdoor applications, the assemblies are fabricated from LMR-600 or LMR-900 cable. The silver-plated connectors include gasketed seals for weatherproofing. Additional weatherproofing and strain relief is provided by an adhesive-backed shrink boot. The assemblies are swept for VSWR and insertion loss over the frequency range of 800MHz to 2,000MHz for cellular and PCS applications. A typical three-foot assembly with LMR-600 cable and DIN plugs has a maximum VSWR of 1.25:1 and a maximum insertion loss of 0.3dB.

Circle (421) on Fast Fact Card

Converter adapts equipment to nonstandard systems



The model 1650-24-12-15 dc-to-dc power converter from **Wilmore Electronics** converts +24V to +12V, providing 15A on a continuous-duty basis. The unit is designed to allow standard 12Vdc negative ground mobile communications equipment to be operated in vehicles with nonstandard electrical systems. The corrosion-resistant aluminum housing measures only 1.9" × 4.5" × 5.5", plus mounting flange and fuse holder. Efficiency is better than 90%, and the operating temperature range is −30°C to +60°C.

Circle (422) on Fast Fact Card

Trunking control console works with Kenwood, Midland radios

The TC-560 trunking radio control console from **Vega Signaling Products** has full compatibility with the Kenwood TK-931 and TK-940, and Midland trunked radios, through a model TC-260 remote adapter panel. The dispatch console features a desk microphone, vacuum-fluorescent alphanumeric display, dynamic level settings and self-testing, and PC access for system setup. Date and time, level setting and command self-test are accessed from a keyboard. The console operates on 12Vdc with provision for battery backup.

Circle (423) on Fast Fact Card

Digital microwave radios feature four-level frequency shift keying

The FSK+ line of digital microwave point-to-point radios from **Advanced TechCom** covers frequency bands from 1,500MHz to 23GHz and is designed to offer hitless error-free receiver switching. Both non-protected and protected system configurations are available. Features include triple forward-error correction, reversible rack-mounting and self-diagnosis. All FSK+ radios employ four-level frequency shift keying (4FSK), a constant amplitude digital modulation scheme. A proprietary Application Specific Integrated Circuit (ASIC) device performs all digital radio modem functions, including digital multiplexing and demultiplexing, scrambling and descrambling, and error correction coding and decoding.

Circle (425) on Fast Fact Card

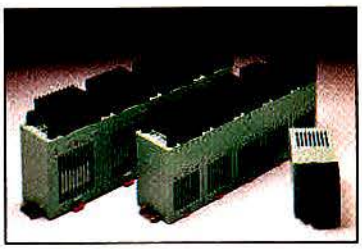
Dash-mount mobile's compact design allows vehicle mounting flexibility

The GX1510 dash-mount mobile from **Standard Communications** is designed for flexible installation anywhere in a vehicle. The 25W, 10-channel radio operates on VHF and UHF bands. Channel number, operational and status information are shown on a high-visibility backlit LCD. All CTCSS/DCS tones are included. Other features include priority channel, one-touch scanning, busy-channel lockout and field programming. Non-volatile memory stores programmed frequencies.

Circle (424) on Fast Fact Card

New products

Power supplies rail-mount into panels, cabinets



Phoenix Contact offers a line of compact DIN-rail-mountable power supplies that mount into control panels or marshaling cabinets. A quick-snap mounting system allows use with other similarly mounted components. All power supplies feature enclosed, dead-front housings. Outputs are rated at 5Vdc, 12Vdc, 15Vdc, ±12Vdc, ±15Vdc and 24Vdc at a maximum of 5A in the regulated versions. Unregulated units are also available, to 10A.

Circle (426) on Fast Fact Card

Software simplifies site acquisition, management

SATCAD site acquisition software from **Mobile Systems International** is a PC-based software tool for use in the United States and Canada that simplifies site selection and management. A user manages site information through flexible Windows-based data input along with imported digital images of site photos and scanned lease forms. Using the RF Prediction option, the user is able to make better-informed analyses of site candidates. SATCAD also simplifies compliance with regulatory requirements by incorporating FCC and FAA site databases.

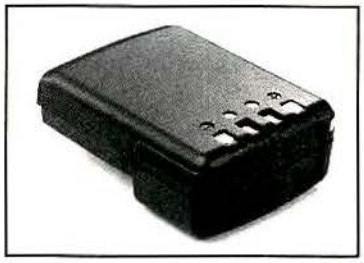
Circle (427) on Fast Fact Card

Platform applies prepaid calling cards to cellular

Open Development's wireless version of its prepaid calling card system is designed to be a reseller platform. The network-based prepaid cellular system, OpenMedia Cellular Prepaid, is aimed at increasing service providers' revenue by overcoming barriers to business development, such as customers turned down due to credit requirements and financial exposure to roamer fraud. Features include real-time call rating and billing, fraud control and prevention, and call branding.

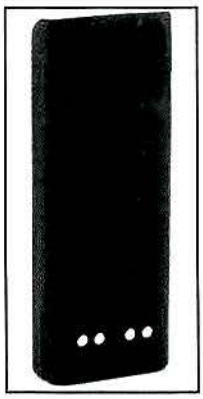
Circle (428) on Fast Fact Card

Replacements match Alinco batteries, eliminator



Alinco replacement batteries and a battery eliminator for the DJ-190/DJ-G5 are available from **W & W Associates**. The WC-530A-EBP-37N is rated for 4.8V at 800mAh. The WC-530A1-EBP-34N(S) is rated for 4.8V at 1,500mAh. The WC-530B-EBP-35N is rated for 7.2V at 900mAh. The WC-530C-EBP-36N is rated for 9.6V at 650mAh. The WC-530B1-EBP-35N(S) is rated for 7.2V at 1,000mAh and is 0.6" longer than the original case.

Circle (429) on Fast Fact Card



Replacement battery fits Motorola mobile radios

JBro Batteries has added the high-capacity JB-7144 to its line of land mobile batteries. The 7.5V replacement is for Motorola HT-1000 and MT-2000 land mobile radios.

Circle (430) on Fast Fact Card

Lightning arrestor steps down incoming current to downline arrestors

The FlashTrab lightning current arrestor from **Phoenix Contact** steps down initial incoming lightning currents to coordinated downline arrestors such as the ValveTrab MS. FlashTrab can extinguish a 60kA, 10×350μs lightning waveform test to a 4kA level. ValveTrab MS installed in conjunction with FlashTrab further reduces the residual 8×20μs waveform produced from FlashTrab. The combination of the two units forms a tight voltage control system to protect electrical and electronic equipment. Both modules pass lightning currents to earth ground.

Circle (431) on Fast Fact Card

Modular data link performs as multiplexer, cross-connect, rate bridge

SiteLink from **SmartLink Development** is a multi-rate, digital multiplexer, cross-connect and rate bridge designed to use and move a variety and combination of communications media, data and bandwidth. The modular unit is applicable with voice-grade two-wire, voice-grade four-wire, asynchronous data, synchronous data and alarm circuits. SiteLink is compatible with unlicensed spread spectrum radios in the 902MHz–928MHz and the 2,400MHz–2,480MHz bands. The unit offers a universal card cage, consisting of 16 slots, available for any combination of modules. As many as three card cages can be stacked and interconnected for high-capacity applications.

Circle (432) on Fast Fact Card

Gateway software allows receipt of pager E-mail without Internet address

AlphaPlus E-Mail from **Paging Partners** is gateway software that allows pager users to receive LAN-based E-mail messages without having to establish an Internet address. The program copies messages directly from the user's current E-mail software (Microsoft Mail, cc:Mail or Lotus Notes) to an alphanumeric pager, without a special address or subscription to an Internet ramp service. The user can customize the type and amount of information forwarded. Messages can be screened by sender, subject and priority level. All messages are retained on the recipient's PC, whether or not they are selected for forwarding. The software runs under Windows NT, DOS and OS/2.

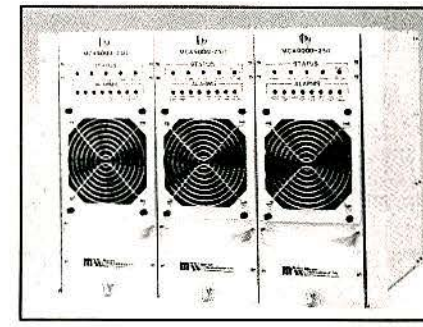
Circle (433) on Fast Fact Card

Fiber optic/coax configuration provides wireless for in-building, tunnels

A configuration that uses radiating coaxial cable and fiber optics to provide paging, cellular and PCS services for wireless communication in-building and in tunnels is available from **Andrew**. Applications include providing network operators with both RF analog and digital services in locations such as underground mass transit systems.

Circle (434) on Fast Fact Card

RF power amplifier frame fits need for 19-inch rack-mounting



Milcom International now offers the MCR3000-1, a standard 19" frame to complement its existing 26" frame model MCR4000-1. The new frame accommodates various communications standards including AMPS, CDMA, TDMA, TACS, SETACS and ETACS. Combined with Milcom's standard 30W average power MCA9000-250 amplifier modules, the frame and amplifier are capable of maintaining 260dBc IMD with average power available from 25W to 50W per module, and expandable to 200W.

Circle (435) on Fast Fact Card

New products

Microstrip cellular panel antennas accept tower, wall mounting options

Sinclair Technologies has released a series of compact microstrip panel antennas for cellular applications that can be tower-mounted or mounted flat to the side of a building. The radomes for the SRL-4060 and SRL-4090 series are constructed of impact-resistant polymers. The units resist impact, chemicals, fire, and UV radiation and offer low water absorption. The antennas feature null fill, low side lobes, high front-to-back ratios, low-loss feed, high power-handling capabilities and low passive intermodulation. Downtilt is available as an option, and mechanical downtilts are also available. The antennas are available in 60° and 90° beamwidths and feature gains from 9dBd to 15dBd.

Circle (436) on Fast Fact Card

Circle (103) on Fast Fact Card

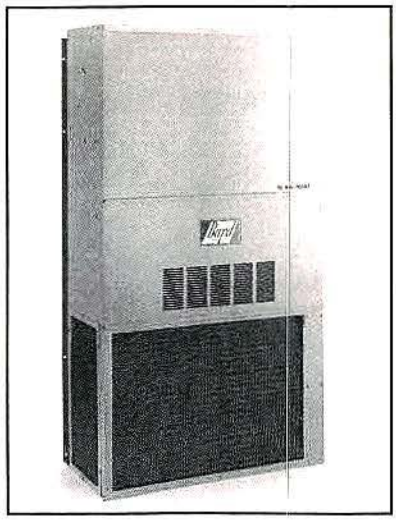
Circle (104) on Fast Fact Card

Modulation spectrum analyzers cover multiple digital standards

The models R3263 and R3465 Advantest spectrum analyzers available from **Tektronix** are designed for digital mobile radio and PCS applications. The full-featured analyzers include multi-standard modulation analysis, color display and automated measurements. The R3465, with a range of 9kHz to 8GHz, addresses the NADC, PDC and PHS standards. The R3263, with a 9kHz to 3GHz range, covers standards based on GSM.

Circle (437) on Fast Fact Card

Wall-mount ac unit allows access for service, side-by-side placement



Bard Manufacturing's vertical wall-mount WL series air conditioner with left side control panel provides complete service access when two units are mounted side-by-side in an equipment shelter. The units feature high/low pressure switches, adjustable compressor time delay relay, low ambient control and alarm relay contacts. An optional economizer reduces compressor run time. Cooling capacity is 18,300BTUH to 57,500BTUH, with 230V/208V and 460V three-phase units available.

Circle (438) on Fast Fact Card

Link for SMR creates opportunity for multisite land mobile systems

The SMRLink site controller from **SmartLink Development** is trunking and networking technology designed to open the door for multisite land mobile radio systems. The controller translates nearly all major trunking or conventional protocols so they can operate together in the user's system, including LTR, GE Marc V and VE, DCD and IDCS, and CTCSS for 800MHz, 900MHz, 220MHz and 450MHz. Other features include cross-banding, "follow-me" roaming with hand-off of calls in progress and DID/DOD capability. Module shelves occupy 7" × 19" and require single source 11Vdc/16Vdc. Other voltages are optional.

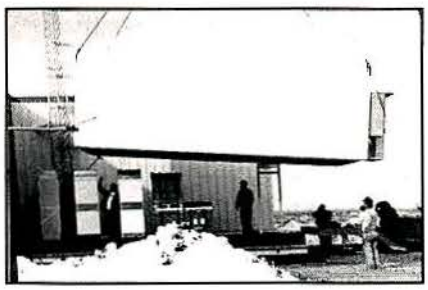
Circle (439) on Fast Fact Card

Non-commercial radios support pleasure applications at 460MHz

Motorola Land Mobile Products has expanded its Sport Radio line of two-way radios for non-commercial pleasure use with the Sport 7 portables. Operating on 460MHz FM UHF, the radios are designed for family use and outdoor activities. The radios have a talk range of two to five miles.

Circle (442) on Fast Fact Card

Universal comm shelter features lightweight design, durability



The Switzer 9000 series composite enclosures are available as communications enclosures for cellular, PCS, microwave and fiber optic installations. The shelters from **Switzer Products** feature a lightweight design represented only 10% of the weight of equivalent concrete shelters while still providing for snow loads over 70 pounds and 150mph wind loads. The shelters are secure against moisture penetration and resist salt air, acid rain or chemical environments. Options include floor systems, bulletproofing, HVAC and lighting.

Circle (440) on Fast Fact Card

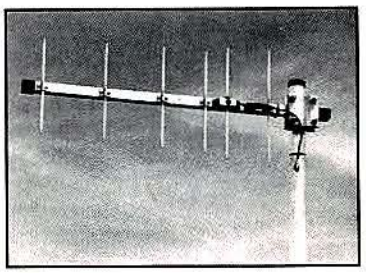
UHF portable features six channels, switchable power, programmability

Vertex Radio Communications has added a UHF version (410MHz–512MHz) of its Vertex VX-200 to its portable radio line. The lightweight portable has a MIL-STD 810 D/E rating and is PC-programmable. Features include six channels, 5W/1W selectable RF power output, extended battery life, power saver, CTCSS and DCS. Trunking and encryption options are also available.

Circle (441) on Fast Fact Card

New products

Yagi antennas feature heavy duty commercial design

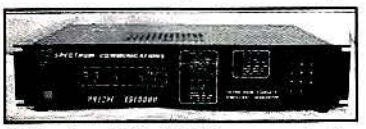


Antennaco's model 460-6H heavy-duty yagi antenna incorporates heavy-duty fabrication upgrades. The antenna design includes a thick-wall square tube boom with a full one-inch cross-section at the core to withstand high winds and ice loading. Each rod element on the antenna is high-strength aluminum.

Circle (443) on Fast Fact Card

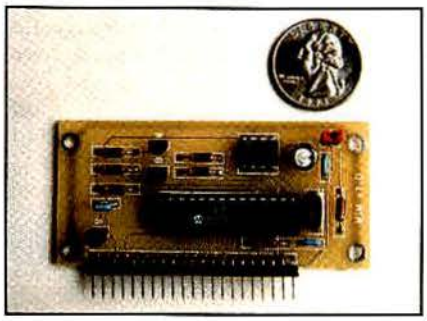
Frequency generator stabilizes paging transmitters

The Spectrum SS10,000 is an ultra-high-stability frequency generator for use with simulcast paging and repeater transmitters. The unit from **Spectrum Communications** provides 0.002ppm stability needed for simulcast, along with FSK digital and analog modulation. The frequency generator accepts any digital format to 2,400 baud and can be upgraded to 6,400 baud with 4-level shifts. An LED full-front panel displays frequencies, shifts and control modes. A direct digital synthesis design allows frequency and shift changes to 1Hz.



Circle (444) on Fast Fact Card

Unit adapts FM transmitter for packet-form GPS data, telemetry



The MIM module from **Clement Engineering** is a miniature APRS-compatible packet-radio telemetry unit. When attached to a suitable FM transmitter, the unit can send APRS GPS position reports, analog and binary telemetry data in packet form, beacon text messages and a CW Morse ID. The unit accepts GPS data for position reporting and can telemeter five A/D inputs as well as eight bits of parallel digital data.

Circle (445) on Fast Fact Card

Charger/amplifier combination converts portable radio into a base station

The Jerk and Run EC series units from **BK Radio** combine a portable radio with an RF amplifier and a vehicular charger, allowing a portable radio to be used as a base station. The ECH59 0JA and ECU49 0JA models include a 50W broadband amplifier and allow any Bendix/King VHF or UHF portable radio to be inserted into a metal housing that charges the battery. When a portable radio is required, the Jerk and Run feature allows the user to flip a lever that releases a spring-loaded mechanism that ejects the radio. Standard features include a transmit LED indicator, radio-locking mechanism, 7W audio amplifier, dead battery override and an under-the-dash speaker.

Circle (447) on Fast Fact Card

Communications analyzer offers two formats for digital iDEN testing

The R-2660B Communications System Analyzer from **Motorola Communication Test Equipment** has dual-mode iDEN capability covering both 3:1 and 6:1 digital radio test formats. The model R-2660B adds the 3:1 format test capability to the iDEN 6:1 testing provided by the original R-2660A unit. For subscriber units, the analyzers offer dynamic call testing of dispatch and interconnect calls, live voice verification and comprehensive test mode support. For site equipment, the R-2660 series offers transmitter and receiver testing in test mode and live site monitoring capability. Motorola is also offering a conversion kit to provide R-2660A users with the 3:1 format capability of the R-2660B. Both models provide a selection of general-purpose test capabilities, including a spectrum analyzer with a tracking generator, cable fault testing and an oscilloscope.

Circle (448) on Fast Fact Card

Common time base maintains optimal bit error for MAS radios

The GatorTrak feature from **Alligator Communications** maintains optimum bit-error rate in an MAS radio network. The system uses a common time base in the master station operating in concert with remote radios equipped with automatic global frequency calibration. A single adjustment at the master station will calibrate all of the master transmit and receive modules, while providing a calibration standard for the remote radios to automatically adjust against. A second common time base with automatic switchover is provided for redundancy.

Circle (446) on Fast Fact Card

New products

Analyzers allow site tests for low-frequency fields

Wandel and Goltermann's EFA-1 and EFA-2 electromagnetic field analyzers measure non-ionizing low-frequency magnetic field strength from 5Hz to 30kHz. The battery-powered instruments operate for 10 hours on rechargeable NiCd batteries or for 20 hours on five AA alkalines. An omnidirectional magnetic probe is built into the unit, or an optional H-field probe may be used. The EFA-2 has data-logging capability for unattended, 24-hour measurements. Both analyzers display measurements in nT, mT or mG.

Circle (449) on Fast Fact Card

Coaxial connectors fit cables from TMS, Belden

Twelve coaxial connector styles are available from **RF Industries** to fit Times Microwave Systems LMR-400 cable. The connectors are also useable with Belden 9913 and 9914 low-loss cables. BNC, N, TNC and UHF interfaces are available currently, and 7/16 DIN male and female styles will be released during 1996. Nickel and silver plating is available. All connectors have a Teflon dielectric.

Circle (450) on Fast Fact Card

EMP protectors guard against voltage surges

Spinner-manufactured EMP protection devices designed to guard against high voltage surges caused by lightning strikes at cellular, paging and PCS sites are available from **Precision Tube**. The products are available in two types for in-line transmission use and are compatible with all 7/16 coax connectors. Spinner EMP models include the model 75-64-29 quarterwave shorting stub for use in the 880MHz to 960MHz band and the model 19-42-02 sparkover shorting type with replaceable gas cells for the entire range of communications frequencies.

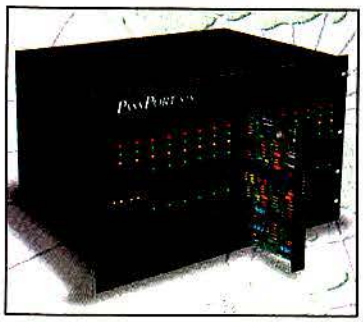
Circle (451) on Fast Fact Card

Replacement batteries, eliminator match Icom models

W & W Associates has available replacement batteries and a battery eliminator for the Icom IC-W31, IC-21A, IC-T22A and IC-T42A. The BP-172 is 4.8V at 950mAh. The BP-180 is 7.2V at 600mAh. The BP-173 is 9.6V at 650mAh.

Circle (452) on Fast Fact Card

Digital cross connect supports various protocols



The PassPort NS from **Trident Micro Systems** is a build-as-you-go infrastructure for analog and digital system needs. The digital cross connect switching device supports various increased conversations-per-channel protocols. Features include 60,000 ID codes per system, Busy-Q support in a message trunking mode, local and remote alarm reporting, and system backward compatibility with analog. The unit supports selective calling between two mobiles in the same fleet or optional fleet-wide calling. The system supports T-1, E-1, ISDN and frame relay, and all digital wide-area networks.

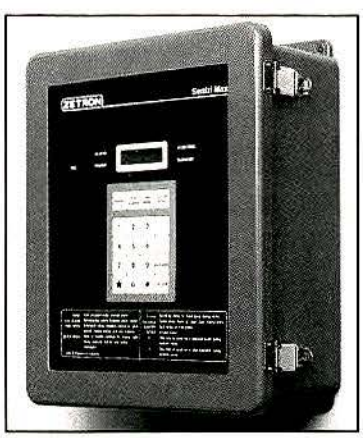
Circle (453) on Fast Fact Card

Test instrument emulates cellular base station

The TAS 6600 Wireless Communications Analyzer from **Telecom Analysis Systems (TAS)** evaluates the performance of cellular voice, data and image communications equipment. The analyzer offers complete cellular base station emulation. Each 6600 includes an analyzer mainframe with EAMPS emulation, a cellular audio processor module and Windows-compatible software. The analyzer also can be used to test the major RF and audio functions of radio receivers.

Circle (454) on Fast Fact Card

Paging autodialer sends messages on wireless networks



The SentriMax 1550 alarm monitor from **Zetron** is capable of paging voice or alpha messages over local wireless networks. The monitor can dial into wide-area paging services and autodial directly to a list of message recipients. SentriMax monitors as many as 72 contact closures and analog values for programmable alarm conditions. Voice messages are user-recorded into battery-protected solid-state memory. Features include a panic button alarm, a built-in microphone, speaker and a front-panel keyboard with LCD. Users can call the monitor anytime for spoken reports of input status and analog readings of industrial or security applications.

Circle (455) on Fast Fact Card

New products

Data transceiver builds point-to-multipoint networks

The Pathfinder Explorer 9600 is an intelligent UHF 9,600-baud radio data transceiver. The unit from **Metric Systems** provides a plug-and-play solution for building point-to-multipoint asynchronous data networks for industrial control, monitoring and data acquisition. Features and capabilities include three-wire and RS-232 interfaces, packetized or transparent mode, individual station addressing, and full error detection and correction. The transceiver is available in seven bands from 403MHz to 512MHz.

Circle (456) on Fast Fact Card

Wireless data solution delivers E-mail to mobile users

A turnkey solution that allows Lotus cc:Mail Mobile users to automatically send and receive messages at any time from any location has been created by **Wireless Telecom International** using products and services from GTE Mobilnet, Motorola and Sierra Wireless. Built around Air*Mobile* software from Motorola, the bundled solution delivers E-mail to users automatically, regardless of location. Because charges are based on the amount of data transmitted, not connect time, the combination of Air*Mobile* and GTE Mobilnet cellular digital packet data (CDPD) service makes it possible for the user to have the cost-effective, full-time connection required to operate in a virtual office environment. The bundle serves five mobile users and includes a five-pack of Motorola's software, CDPD airtime from GTE Mobilnet, six PocketPlus multimode modems from Sierra Wireless (five mobile, one host) and 30 days of free technical support from Wireless Telecom.

Circle (457) on Fast Fact Card

Wall-entry system provides lightning strike protection

The ArrestorPort-Plus is a transmission line wall-entry and grounding system designed to maximize protection from lightning strikes. The system from **Andrew** arranges transmission line entry ports into a simple, multi-row unit that provides easy installation for transmission line and surge protectors. The design accommodates outdoor installation of the Arrestor Plus surge protector to the integrated ground bar assembly. This routes damaging transients of a lightning strike away from equipment on the outside of an equipment shelter.

Circle (458) on Fast Fact Card

Literature

Catalog offers technical information on power products

A 61-page catalog gives research and development and production engineers the latest technical information on alternating current sources, direct current power supplies, electronic loads, harmonic and flicker test systems and solar-array simulators for the lab or factory. The 1996/97 *Power Products* catalog from **Hewlett-Packard** features new products such as the HP 6840 series Harmonic and Flicker test systems for IEC 1000-3/EN 61000-3 compliance testing and enhanced 3,000VA single-phase and 4,500VA three-phase ac power source/analyzers.

Circle (251) on Fast Fact Card

Book explains fundamentals of wireless communications

Wireless Basics by Harry E. Young describes the profusion of wireless telecommunications services, such as cellular, paging and PCS and how they interconnect with the existing landline telephone network. The 152-page book from ***Telephony*** magazine describes each of the wireless services, giving a brief history of the service, its radio spectrum requirements, pertinent regulatory considerations, basic system architecture, typical interconnection requirements, numbering needs and typical call processing procedures. Introductory chapters give the groundwork for concepts and terms, such as the North American Numbering Plan and Signaling System #7, that are used in later chapters. The book contains 34 illustrations, eight tables, a glossary and an index. It is the latest in a seven-book "Basics" series from *Telephony*. Other books in the series are *Telecom Basics, SS7 Basics, SONET Basics, LAN Basics, Transmission Basics* and *Datacom Basics*.

Circle (252) on Fast Fact Card

Selection guide covers variety of telecomm products

The 1996 product selection guide from **Marketronics** contains more than 200 pages of telecommunications products from more than 40 manufacturers. Base station antennas, coaxial cable and connectors, duplexers, mobile antennas, power supplies and two-way radios are examples of the types of products inside.

Circle (253) on Fast Fact Card

Book discusses principles of mobile communications

Source-matched Mobile Communications by W.C. Wong, Raymond Steele and Carl-Erik W. Sundberg introduces the reader to the principles of mobile communications and determines link performances for different types of speech coding, error coding and modulation methods. The book from Pantech Press and **IEEE Press** includes chapters on such topics as an introduction to digital cellular radio, transmission errors in binary modulated PCM systems, source-matched digital transmission of DPCM speech; and source-matched digital transmission of subband coded speech.

Circle (254) on Fast Fact Card

Catalog describes new measurement products

A 600-page soft-cover 1996 *Measurement Products Catalog* from **Tektronix** includes a color new product section that presents a synopsis for the company's business focus and features a variety of new form-factor measurement solutions. The catalog descriptions are backed by an on-demand fax service, available via a toll-free 800 telephone number, offering extensive application and technical notes. Indexes in the catalog list products by name and by function.

Circle (255) on Fast Fact Card

Literature

CD-ROM package provides interactive training and reference

An interactive training and reference source for the GSM community is available from London-based **AirComm International.** The CD-ROM package can be used on any PC platform and provides in-depth and user-friendly training on all aspects of GSM and DCS systems. The unique encyclopedia provides step-by-step tutorials for technical and non-technical users alike. Subjects and features include introduction to cellular radio; introduction to GSM; radio interface operation; network operation; radio propagation; and radio and network planning. The package is supported by animated diagrams and C++ Windows programs, and a wide range of manufacturers' GSM and DCS equipment is fully illustrated.

Circle (256) on Fast Fact Card

Catalog lists antennas, accessories

A 23-page cellular antenna and accessories catalog from the Antenna Specialists division of **Allen Telecom Group** contains top-selling lines of mobile cellular antennas, ranging across all mounting type and gain levels. The catalog includes four- and seven-element yagi antennas; unity gain transmit antennas; marine cellular antennas; and easily detachable portable and transportable antennas. The catalog also contains the new ActiveLink LE in-vehicle repeater, as well as a wide array of cable, connectors and crimping tools, replacement whips and installation test equipment.

Circle (257) on Fast Fact Card

Technical data sheets cover EMI/RFI shielded doors

Technical data sheets from **Lindgren RF Enclosures** detail the company's high-performance EMI/RFI shielded doors, which are designed to meet a range of access and RF performance needs for EMI/RFI shielded enclosures. The data sheets cover the Double Knife Edge door, the Pneumatic Sliding door and the Pneumatic Hinged door. All doors exceed the requirements of NSA 65-6 and CID/09/12A when tested in accordance with MIL-STD 285 and all can be integrated with a variety of closure and interlock devices.

Circle (258) on Fast Fact Card

Catalog covers coaxial connectors

A 100-page catalog describes an expanded range of coaxial connectors, including 300 new items. Connector types include BNC, TNC, N, UHF, mini-UHF, MB, SMB, SMA, MCX, 7/16 DIN, FMR, LMR series, ½" and ⅞" corrugated cable connectors. The catalog from **RF Industries** also includes 1,500 coax products, including cable assemblies, connector kits and Unidapt and Celludapt universal adapter products, cellular products and hand tools.

Circle (259) on Fast Fact Card

Catalog contains listings for wireless industry books

A 76-page catalog from **Artech House** contains descriptions of hundreds of recently published professional books, software and video training courses on topics ranging from wireless communication networks, computer security and satellite communications to smart sensors, antenna design and multisensor data fusion.

Circle (260) on Fast Fact Card

People

Steven L. Deppe departs Dukane, St. Charles, IL, as president of the Communications Systems division to join Maxrad, Hanover Park, IL, as chief executive officer.

Bruce Edwards leaves AST Research as executive vice president and a member of the board to join Milcom International, Irvine, CA, as president and a board member.

Changes at PanaVise Products, Sparks, NV:
Anita Schreiber, a sales administrator, advances to sales manager.
Nick Costulas exits Tessco, Sparks, MD, as outside salesperson for infrastructure products to join PanaVise in the area of field sales. He will be based in Schaumburg, IL.

Joel Young departs AT&T, Chicago, as district manager for both AT&T Bell Laboratories and Business Communications Services to join Transcrypt International, Lincoln, NE, as vice president of engineering.

Changes at Allen Telecom Group (ATG), Cleveland:
Mark Gross, regional sales manager, moves up to eastern sales director.
Bill Crank, regional sales manager, advances to central sales director.
Lawrence Taylor, major accounts manager, moves up to western regional sales manager.
Patty Fritz, national distribution sales manager, advances to national sales manager.
Ken Czosnowski, midwest major accounts manager, moves up to original equipment manufacturer (OEM) sales director.
Shawn Cooprider departs AT&T Wireless Services, Seattle, as corporate account executive to join ATG as major accounts manager.
Samuel Schanker leaves Southwestern Bell Mobile Systems, Dallas, as manager for wireless development to become a major accounts manager for ATG.
Thomas Vornholt, formerly a manufacturers' representative for ATG, becomes a major accounts manager.
Frank Belluccia leaves Ericsson Private Radio Systems, Lynchburg, VA, as a major account manager to join ATG as a major accounts manager.
Thomas Macken departs GTE Mobilnet as a technical sales representative to join ATG as a major accounts manager.

Carl Robert Aron departs A.T. Kearney, a subsidiary of EDS, as national director of the wireless and the utilities telecommunications consulting practices to join Itron, Spokane, WA, in the newly created position of chief operating officer.

Changes at SmartLink Development, Wallingford, CT:
Fred Sartorius leaves Nextel, Rutherford, NJ, as regional sales manager for the Southwest to join SmartLink as Western regional manager of sales and marketing.
Bob Batten departs Midland LMR, Kansas City, MO, as area sales manager to become sales manager for the Southeastern region at SmartLink.
Ed Kuter ceases doing business as an individual contractor in sales and marketing of fiber-optic, microwave and switching systems to commercial, government and regulated utilities to join SmartLink as manager of the SiteLink Products line for sales and product management.

Letters from readers

Fast Fact Card comments:

The toughest problem facing me on the job is government red tape.

John Sippel
Manager
Sippel Hardware & Communication
Universal City, TX

The toughest problem facing me on the job is raising repair costs.

Richard Willbanks
Vice President/SLS
Law Enforcement Sales
Kennesaw, GA

The toughest problem facing me on the job is the budget.

Peter W. Kyryl II
U.S. Coast Guard Auxiliary
Santa Cruz, CA

The toughest problem facing me on the job is competing against dealers with no service or support products—low overhead; no service; low prices.

Paul B. Boudreau
All Comm
Revere, MA

The toughest problem facing me on the job is that there are two campuses that are 2.3 miles apart with one 900MHz, five-channel trunked system.

John Burtis
Boston University
Boston, MA

The toughest problem facing me on the job is portable radio communications. We have a hard time on WTs. No one can hear us on WTs.

Roberto Irizarry
Volunteer firefighter
Polk County Fire/Rescue
Lakeland, FL

The two toughest problems facing me on the job are:

- Heavy intermod at commercial repeater sites.
- Finding ways to save on new equipment.

Richard Sandel
President
Robert Reed Associates
Larchmont, NY

The toughest problem facing me on the job is finding a radio that is easy enough for customers to use and sophisticated enough to provide a solution for their needs.

Aaron Clark
Don Clarks Radio
Blackfoot, ID

The toughest problem facing me on the job is alignment on pagers.

Oscar Schiappacasse
Omega Tele-Comm
San Juan, Puerto Rico

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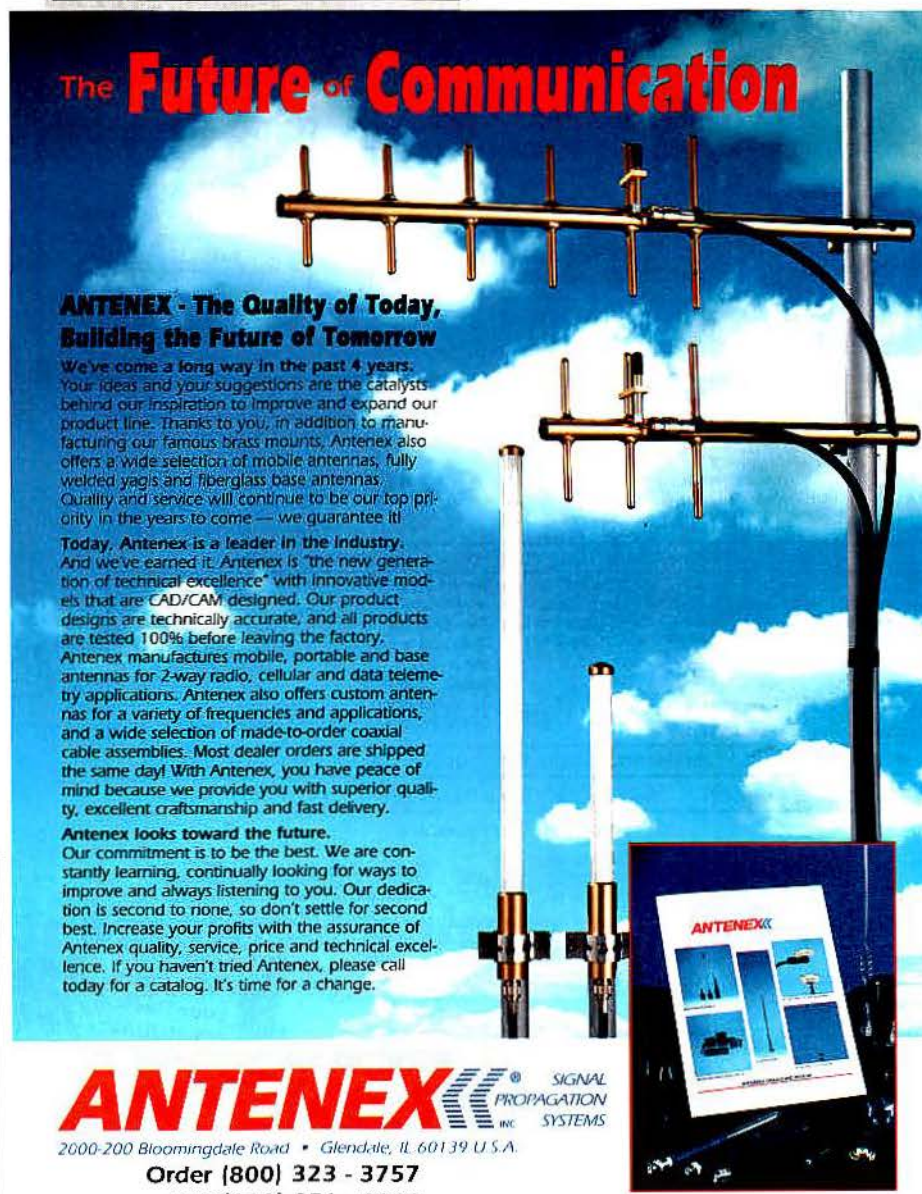

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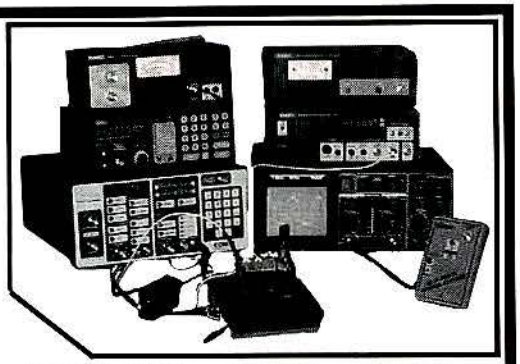

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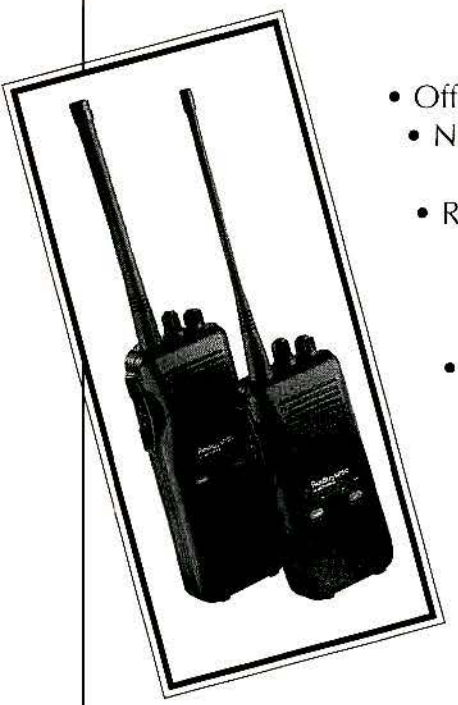
Presented are 15 reasons which is our renewal of past New Year's resolutions:



- Prompt Courteous Service
- Offices throughout the U.S. to provide assistance on a local basis.
- No Gimmicks/Substitutions, unless you request otherwise. You r receive product as it is received from the factory.
- Rotation of product so you receive the most factory fresh product with the latest updates in them.
- Programming for the life of the radio (trunking excluded) at no charge.
- In most cases No-charge Shipping with full insurance coverage.
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- An added 90 Day Warranty on all new products, paid for by *ProComm.*
- A minimum of 0.5 million dollars of product on hand at all times to meet your needs.
- We accept your late model Motorola equipment in trade to reduce your cash outlay.

We are continually upgrading our phone system to minimize your wait and loss of valuable time.

- Direct Access to the companies' owner to discuss your concerns, suggested improvements , etc.
- We provide customer references throughout the U.S. that are commited to *ProComm.*
- We have absolutely no competition and never compromise integrity.
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80	Rockwell (DTL Type) Programmable Channel Modems, VGC	$100
30	DTL 7300 & Rockwell Modem Shelves	$125 ea
40	Motorola Syntor X9000, 800 MHz	$225 ea
20	Johnson 8605	$175 ea
50	Micors, 110Watt, VHF-Hi, Good Condition	$125 ea
50	Mitreks, 30-39 PL, 110Watt, Good Condition	$250 ea
1	Micor 330watt 36-42, PL, Good Condition	$1500 ea
800'	6 Ghz Ecliptical Waveguide In 200 Lengths	$500 ea roll
3	Racks of Lenkurt 79 F1 600 Channel with Hot Stand-by 2 GHz Good Condition	$1500 ea
6',8',and 10'	Andrews Microwave Dishes, Some With Radoms, 2 GHZ and 6 GHZ Feed Horns MC 400 Term Cards	Call
3	T1617 Consoles	$250 ea
50	MT 500, UHF, 4-Channel, PL, 4 Watt, W/Charger & Bat	$90 ea
60	GTE Lenkurt 3612 Channel Modems	$50 ea
50	Motorola MC 400 MLN 6153 Channel Modems	$100 ea
50	MC 400 Term Cards	$50 ea
3	Micor Base Stations, 100W 42-50, PL, Good Cond	$950 ea
50	GE Ex II, 60W, Multi-Ch., Good for 6 Meters	$60 ea
40	GE Delta-SX, 110W, 42-50 Ch. Guard, w/Acc. Good Cond	$225 ea
30	GE Mastr II 100 W 42-50 Ch Guard w/Acc	$125 ea
6	Motorola Syntor X Trunked, Smart-Net, Dual Operation Control Station NEW Condition	$250 ea
10	Mitreks, UHF, PL, Multi-Ch., 50 Watts	$150 ea
20	Mitreks, 42-50, PL, Multi-PL, 60 Watts	$150 ea
20	Micors 45W Sys. 90 Scan, Multi-PL, UHF	$75 ea
20	Mocom 70s 42-50 PL 100W w/Acc.	$100 ea
15	HT 220, 4W, PL, UHF w/Charger and Battery	$50 ea
10	T1605 w Mic's	$125 ea

Call Charles at CMC Enterprises, 910/769-2885

call Michele @ 913-967-1861 for more information about advertising

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New stock PE/MPX/PMII Parts	call
PC202S VHF PCS Port. w/new batt.	$285
GE Mobile repeater, VHF w/cable	$65
MPI UHF 4W tech special	5/100
MPI 8-unit multicharger, checked	$40
Ranger new 29-43 less acc. 100w	$325
Rangr 450-470 less acc. 100W	$325
Delta-S 136-155 less acc. 40 W	$100
Delta-S 450-470 less acc. 100W	$295
Delta-S 450-470 40W S-990 acc.	$299
Delta-S 450-470 40W no acc.	$150
Delta-S 42-50 less acc. 110W	$150
MVS Control panel 16 ch scan	$60
MLS-I Control panel 8 ch scan	$65
MLS -I Cont. panel 16 ch no scan	$60
Speaker mic. PCS MRK	$35
19B801586P2 MPA/MPD Speaker mic.	$30
Phoenix-SX VHF 16 ch. scan no acc.	$125
DSTA01 Desk top station, new	$140
19B234804P12 MPD/MPA Ant. new	$8
MASTR II 150-174 110W from	$115
MASTR II 42-50 110W w/acc.	$165
S-990 128 ch. head w/warranty	$125
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PCS Rapid desk chrgr, NEW	$60
MPS/MPR/MPX/MPI/MPD Chargers	call

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11 ea. SPECTRA, 900 MHz, D37KGA5JB9LK
8 ea. SPECTRA, 800 MHz, D45KGA5JB7AK
6 ea. SYNTOR XX 800 MHz, T45XAJ5G11AK
34 ea. MOSTAR 800 MHz, D45TLA5G00DK
3 ea. MICOR Repeaters, 800 MHz C75RCB6108BY
2 ea. MICOR Bases, 460 MHz, B84RCB1105AT
3 ea. GE MASTR II Bases, 460 MHz, VC85RAS88B
30 ea. MICOR, 460 MHz, T54RTA6903
16 ea. MICOR, 460 MHz, T54RTA3903
7 ea. MITREK, 460 MHz, T44JJA6900
2 ea. MAXAR 50, 460 MHz, D34JJA3300AK
4 ea. MAXAR, 460 MHz, D34TGA3300DK
25 ea. MAXAR Power Supplies
10 ea. MT500, 460 MHz, H34BBU3124
17 ea. SYNTOR, 155 MHz, T83SRA3200
1 ea. MITREK, 153 MHz, T83JJA3900
24 ea. MITREK, 153 MHz, T43JJA3000
6 ea. PT500, 155 MHz, P33BBM3120AM
10 ea. P50 Portables, 154 MHz, H33GNU7120AN
90 ea. MINITOR I Pagers, 155 MHz, H03EAB1212A
2 ea. MICOR Bases, 47 MHz, C71RTB3405
9 ea. SYNTOR X 9000, 47 MHz, T71KEJ7JO4AX
2 ea. SYNTOR X, 47 MHz, T51JJA4900
25 ea. MITREK, 47 MHz T81JJA4900
7 ea. MITREK, 48 MHz, T51JJA4900
226 ea. MICOR, 47 MHz, T71RTN3100
10 ea. GE MASTR II, 47 MHz, MC74KTW33
1 ea. MICOR Base, 37 MHZ, C71RTB1406
20 ea. MITREK, 35 MHz, T81JJA4000
2 ea. MICOR Bases, 37 MHz, C71RTB1406
6 ea. Tone Remote Consoles, T1604M
60 ea. Tone and DC Remote Desk Sets, Mixed Models
29 ea. Local Control Desk Sets, T1370 & T1003
3 ea. CENTRACOM I Consoles
75 ea. STX/MX Rapid Chrgrs, NLN8858
64 ea. MT500 Omni Std. Chrgrs, NLN4561
18 ea. MT500 Slimline Rapid Chrgrs, NLN4565
25 ea. MT500, 155 MHz, Mixed Models
110 ea. MT500 Standard Rate Chrgrs
19 ea. PULSAR II, 152 MHz, Mixed Models
2 ea. MICOR IMTS Bases, 152 MHz, Q1404B

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1	Motorola JT 1000 UHF 403-470 H01RDH9PA3AN(demo)	$799
40	Mitrek 110w LB 42-50 w/acc T81JJA8900CK	$295 ea
24	Vertex FTL-1011B4 4f 60w 39-50mhz	$349 ea
3	Kenwood TK-320 UHF 4w 16f portable w/new batt.	$265 ea
3	Kenwood TK-801 UHF 40w 16f	$150 ea
1	Motorola Radius P-200 UHF 2f	$295
1	Motorola HT-600 UHF 2f	$ 350
6	Motorola HT-90 UHF 2f PL/DPL	$125
2	Motorola HT-440 VHF 5w 2f DPL	$125 ea
1	Motorola Tek-5B Micor bench test set	$75
2	IDA RLC LTR controllers w/validation	$575 ea
30	Motorola Pageboy II UHF tone/voice pagers	$20 ea
30	Motorola Pageboy III UHF tone/voice pagers	$40 ea
1	Celwave RMC-800 receiver multicoupler 800 mhz	$600
1	Midland Syntech test set (new)	$90
3	Regency TS-2 scanner w/800 mhz	$75 ea
12	Uniden IMU-3100 UHF 99f 30w	$250 ea
4	Uniden IMU-300K UHF 32f 30w	$195 ea
2	GE Ranger UHF 450-470 110w w/acc	$475 ea
10	GE Ranger Microphones 19B801499P4 (new)	$45
40	GE Mastr II Microphones	$10 ea
1000	60a Buss fuse holders w/40a fuse (new)	$ 5 ea

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1	Regency BTH201B - 152.975 - Desk Mic, 20 watt	120
2	Standard FX60V Base - NEW - 40W - Prog., 2 channel	150
1	MOCOM10 w/paging encoder & PS	125
1	Pulsar T1878 C IMTS Extra nice	125
2	Redicom MX5156-RCC, Internal 2805 decoder, no mics	60
2	Fujitsu FTM15-2588L, clean units, on RCC channels	100
4	Ritron RT-450, 2w with tone, chgs, D-ring & belt loops	75
2	Standard C731L, tone, chg-Sold as pair only, both for	175
1	Shinwa SH405G, 5W, prog chg, mk	190
5	Maxon SP2850, 5w, 10ch., prog, drop-in chg, good cond	190
2	Maxon Cp-520HD, 5w, 4ch, tone, on 462.0375, chg	100
2	Ritron RTE45C-tone, DTMF pad, charger	110
3	Wilson WU1514S, RCC, internal secode smart, clean	75
1	Regency MCU 34, NEW in box	100
1	Regency XLU-1515, Prog - NEW in box	175
2	Wilson WH2507S- New in box	120
5	Johnson Ultracom 507 (450 MHz) w/tone	60

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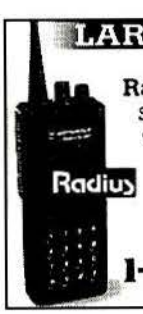

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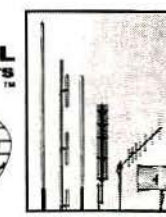
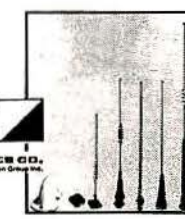


To Mobile....

es the antenna specialists co.



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	UNIT PRICE
RECENT ARRIVALS	
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~~MOT "MSR 2000"~~ SOLD ~~tune rem base, PL~~	~~$1600.00~~
MOT "Flexar" 450MHz, 15w local PL	NEW $200.00
MOT "MCR100" (aka R100) 450MHz, 10w, D PL w/Dplxr	$850.00
MOT "APCOR" 450MHz, EMS Dplx 10w, PL (plus 1-unit parts)	$300.00
MOT "MITREK" Super Consol Base, 4f, scan 30-50/150MHz, PL/DPL	$500.00
MOT Code Synthesizer II (R1151)	NEW $500.00
MOT "Saber" Acc'y Adptr/Hi ruse conn. (NTN 5213)	NEWS35.00
MOT "Saber" Surv Mic/Ppt combn w/ear piece (ZMN 6032)	NEW $90.00
MOT "SP50" rapid charger (NTN 9013)	NEW $28.00
MOT "Mitrek" 150MHz 100w PL/DPL w/545.90 Acc'y	$300.00
MOT "M" Series H/D mic (HMN 1035) w/scuff	NEW $35.00
MOT "M" Series base STN power cord (HKN 9139)	NEW $8.00
MOT "MX/STX" 1 hr rapid chrgr (NLN 8858)	$50.00
MOT "MSR2000" Dplxr 4-cav, 150MHz B/P, P/R	$300.00
MOT "MT500" 42-50MHz 5w, 6f, c/sq	$125.00
MOT "SP50/EXPO" Spkr-mic	$35.00
MOT BNC style 450MHz ant (HT 90 etc)	NEW $2.00
MOT 450MHz Ant "P100" etc syle (early)	NEW $2.00
MOT "Securenet" dvp/Des loading cable for —	
"SYNTORX-9000/Expo" (TKN 9531)	NEW $30.00
"STX/MX" (TKN 8209)	NEW $20.00
"Saber" (TKN 8506)	NEW $35.00
GE "PLS" 450MHz, 4f, 16t, w/o chrgr	$100.00
GE "MPI" 450MHz, 4w, 2f w/o chrgr	$75.00
GE "MPI" 470MHz, 4w, 2f, cg, w/o ant-batt	NEW $60.00
GE "MPI" 150MHz, 5w, 2f, c/s w/o ant-batt	NEW $60.00
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MOT "Saber" 6-unit 1 hr. chrgr (NTN 4798)	$300.00
MOT "HT6000" 6-unit 1 hr. chrgr (NTN 1177)	$300.00
MOT "HT600" 6-unit 1 hr. chrgr (NTN 4668)	$250.00
MOT "P100/HT90" 6-unit 1 hr. chrgr (NTN 5196)	$150.00
MOT "MX/STX" 6-unit 1 hr. chrgr (NLN 8988)	$90.00
MOT "Expo" 6-unit 1 hr. chrgr (NLN 7177)	$150.00
MOT "MT500" 12-unit rapid chrgr	$150.00
MOT "MX/STX" 1-unit rapid chrgr (NLN 8858)	$50.00
MOT "P100/HT90" 1-unit rapid chrgr (NTN 4864)	$30-35.00
MOT "Expo" 1-unit rapid chrgr (NLN 7175)	$50.00
MOT "MT500" 1-unit rapid chrgr/slim (NLN 4565)	$50.00
MOT "HT1000" 1-unit rapid chrgr/slim (NTN 1171)	NEW $45.00
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MOT "MT1000" pub. saf. spkr-mic, UHF (NTN 5493)	$40.00
MOT "STX" New style spkr-mic (NMN 6177)	$50.00
MOT "STX" Old style spkr-mic (NMN 6050)	$40.00
MOT "P50/Expo" spkr-mic	$35.00
MOT "P50/Expo" spkr-mic cord only	NEW $15.00
MOT "Saber" 360° swivel case (NTN 4677 SP2)	NEW $12.00
MOT "MT500" Pub. sfty spkr-mic, brkn back clip (NMN 6083)	$10.00
MOT "STX" c/comm Dtmf mic	$40.00
MOT "Voice Ducer" BDN 6661	NEW $90.00
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GE "MPE" Series Spkr-mic (19D 424867 G3)	NEW $15.00
Standard CMP650 spkr-mic	NEW $25.00
Standard CMP640 spkr/mic	NEW $25.00
Standard CMP 635 spkr-mic as is	3 for $25.00
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MOT "Micor" Rptr 150MHz, 65w c/s w/ cab	$600.00
MOT "Micor" Rptr 450MHz, 25/75w, PL	$1000/1500.00
MOT "Micor" base 36-42MHz, 250w, PL, DC rem	$1000.00
MOT portable repeater, 460MHz, 8f, PL 5/15w (P44 SXS 3180)	$1000.00
GE "Mastr II" base 36-42MHz, 100w, cg tune rem	$600.00
GE "Mastr II" base 36-42MHz, 250w, DC rem	$1000.00

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GE "Exec II" rptr, 406-420MHz, 35w, c/s, w/o cab, base, local	$150.00
GE "Pro" r cvr P.S. w/o r cvr	$50.00
GE "Pro" r cvr w/either 150 or 450 MHz r cvr (icom)	$70.00
GE Sat r cvr tune enc panel (19D4139435 G5)	$20.00
GE "Mastr II" 18/30A base P.S.	$100/175.00
CGE 10A P.S. (mfd by ritz elec) (PS1013MRXFC)	$30.00
GE "Phoenix" Series AC P.S. (19D430175 G1)	$35.00
GE "Pro" Base P.S. (4EP38A-)	$100.00
GE Voting Comparator w/P.S. (grey), 5-Mod-need repair	$150.00
GE "Phoenix" Series 120/220VAC P.S. (19D430225 G1)	NEW $50.00
RJ Comm R cvr multi-cplr 450MHz (RMC-460-116R)	$150.00
RJ Comm R cvr multi-cplr 150MHz (RMC-150-116R)	$150.00
MOT "MRT I" (L 1158) phone patch	$300.00
MOT "MRT I" (L 1159) phone patch	NEW $650.00
MOT "Systel" (L 1574) 2w UHF, DPL w/patch	NEW $750.00
MOT "RBP50" 461-1125MHz, 2w, pgng enc	$175.00
MOT "Modem100" grp 2 paging encoder, 100 call	NEW $100.00
MOT "Spectra-Tac" voting r cvr/comparator chassis only	$50.00
MOT "Spectra-Tac" SOM module - not tstd	$40.00
MOT "Spectra-Tac" SOM module - need repair	$20.00
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MOT "Micor/MSR 2000" base control modules - various	CALL
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MOT "Micor" 100w, c/d P.A. - 25-30/30-36/36-42MHz	NEW $250.00
MOT "Micor" base test set (TLN 1857/TLN 5900)	$40.00
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MOT "TEK-5" meter panel - meter brkn	$35.00
MOT "M-70" super consol (hi power) base w/o radio	$150.00
Astron 12A P.S. (RS-12A) w/cig. lighter plug	$40.00
Astron 12A P.S. (RS-12A) standard	$40.00
Spectrodyne 15A P.S. (GPS-15A)	$75.00
Zetron Model 5 encoder	$150.00
GE "Phoenix" Series desk mic, cg (19B209694 P1)	N/U $35/15.00
MOT/GE/RCA/EFJ/Standard svc manual privr T01985	$10-20.00
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MOT "Maxtrac" 900MHz trnkd 15/35w	$250/300.00
MOT "Maxtrac" 800MHz trnkd 15/35w	$250/300.00
MOT "Maxtrac" 150/450MHz 25/45w	CALL
MOT "Maratrac" 42-50MHz, 100w, w/lim acc'y	$550.00
MOT "SyntorX" 150MHz, 100w, lim acc'y	CALL
MOT "SyntorX" 450MHz, 40w, radio only	$50.00
MOT "Mitrek" 800/450/150/30-50MHz, hi/lo power	CALL
MOT "Mitrek" 40-50MHz, 60W, c/s, w/o tcxo-btm cvr	Clearance $25.00
MOT "Maxar-80" 800/450/150MHz 10-30w PL/DPL	$125-150.00
MOT "Mostar" 150MHz, 40w, 8f w/acc'y	$200.00
MOT "Pulsar II" 150MHz radio only or w/acc'y	CALL
GE "TMX 8825" 800MHz, trnkd - not tstd	$150.00
GE "Classic I" 800MHz, trnkd w/acc'y - nt tstd	$100.00
GE "MLS-I" 450MHz, 40w, 2F	$225.00
GE "MVP" 450MHz radio only - need repair	$25.00
GE "Mastr II" 450MHz 100w w/cr w/o acc'y	$100/200.00
GE "Mastr II" 150MHz, 100w w/cr w/o acc'y	$100/200.00
GE "Mastr II" 36-42MHz, 100w, c/s, w/o acc'y	$50.00
GE "Delta-S" 36-42MHz, 100w, c/s, w/o acc'y	$50.00
GE "Phoenix-SX" 150MHz, 40w, 16t, w/scan	$275.00
GE "MVP" 150MHz, 25w, w/o or w/ acc'y	$25/60.00
MOT "Syntor/Micor" cable - cut at control hd end	$5.00
MOT "SSM" HLN 1300/1198/1222/1225/1241/T5171	$30.00
MOT "X-9000" Control hds HCN 1045/62/65/71/73	$75.00
MOT "DTMF" mic w/auto dial (TMN 6169)	NEW $50.00

	UNIT PRICE
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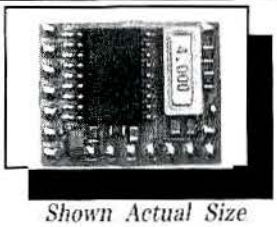

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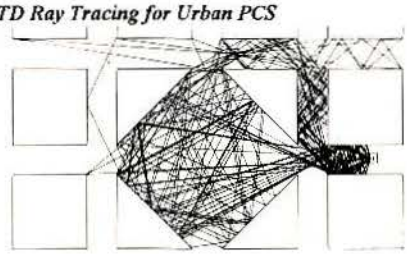

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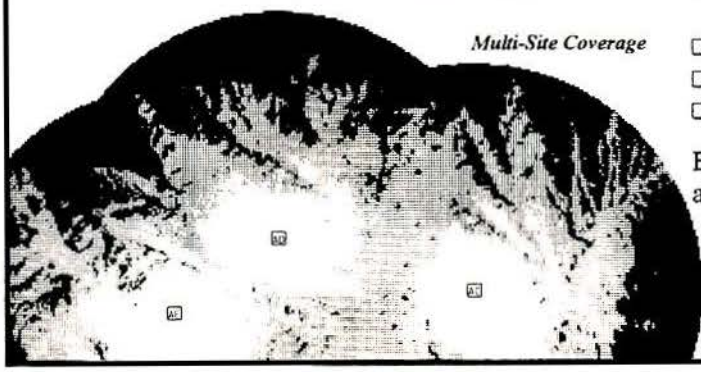

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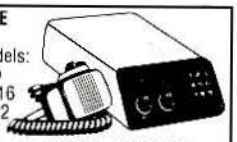

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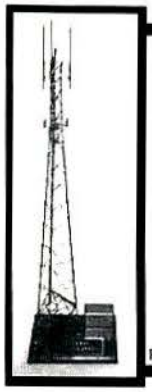

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Circle (181) on Fast Fact Card

Ad index/hot line

Company	Page Number	Fast Fact Number	Advertiser Hotline
Advanced Receiver Research	92	87	203-582-9409
Advanced Videotech Corp.	109	113	800-233-0013
Air Comm	130	168	602-275-4505
AF Comm Supply	129	167	800-255-6222
Alexander Batteries	29	26	800-526-ALEX
Allen Telecom Group	87	80	800-676-5342
Allen Telecom Group	IFC	1	216-349-8400
Anchor Graphics, Inc.	76	68	214-242-0439
Anritsu Wiltron Sales Co.	32 AB,33	29	800-230-2972
Antenex	121	143	800-323-3757
APE South	19	18	800-543-9191
Astron Corporation	49	42	714-458-7277
Avcom of Virginia	91	85	804-794-2500
Barnett Electronics	124	153	800-423-3858
Barnett Engineering.	106	106	403-255-9544
Bird Electronic Corp	88	81	216-248-1200
BK Radio	62,63	54,55	800-648-0947I
Bramco Inc.	106	108	513-773-6255
California Microwave	17	16	800-999-1920
Cartwright Communications	90	83	800-543-8614
Castle Tower Corporation	138	180	713-789-7651
CELWAVE	9	8	800-321-4700
Centurion International Inc.	7	7	800-228-4563
CEO Tronics	108	111	214-416-9500
Chargeguard Corp.	128	163	800-458-3410
David Clark Co.,Inc.	40	35	508-751-5800
Communication Instruments	136		970-962-9998
Communications Data Services	134	175	800-441-0034
Communications Service Co.	132	171	800-875-5109
Communications Specialists	BC	3	800-854-0547
Computer Resources	133	172	205-987-1523
COMTELCO Industries Inc.	24	22	800-634-4622
Connect Systems, Inc.	13	11	800-545-1349
Control Signal Corp	16	14	303-989-8000
Corporation Ten Intl	34	30	410-821-0008
CPI Communications Inc	26	24	214-437-5320
Cromack Industries Inc.	95	90	800-603-5140
Crystronics, Inc.	118	137	305-566-6949
CTI Products Inc.	108	110	513-595-5900
Cushcraft/Signals Corp	23	21	800-258-3860
Daniels Electronics	44	38	604-382-8268
Delta Communications	129	166	800-880-2250
Direct Power & Water Corp.	114	121	505-889-3585
D & L Communications Inc.	123,135	148,177	800-336-6825
Doppler Systems, Inc.	109	112	602-488-9755
Douglas Integrated Software	133	173	800-845-0408
DuraComm Corp.	82	75	816-746-8300
Dynatech Tactical Comms	18	17	603-880-4411
EAGLE	90	84	520-204-2597
Eagle Telecom Intl.	67	60	713-280-0488
EDX Engineering	133	174	541-345-0019
E F Johnson	21	20	800-328-3911
El Paso Communication Systems	110	114	915-533-5119
ELS Communications	124	154	918-664-0980
E Trunk Systems, Inc.	132	170	914-245-1128
Fourth Dimension Industry	79	72	800-378-0348
Gabriel Electronics	100	97	207-883-5161
Gamber Johnson	105	105	715-344-3482
Grayson Electronics	11	9	800-800-7465
Doug Hall Electronics	76	69	614-261-8871
Harger Lightning Protection	100	96	847-548-8700
Hark Electronic Systems Inc	31	27	803-875-4480
Henry Radio	70,128	63,164	800-877-7979
Hewlett Packard Co	119	139	707-577-2265
Richard Hirschmann of AM	78	71	201-835-5002
Hustler Inc.	35	31	800-949-9490
Hutton Communications	41	36	800-442-3811
Hy-Q International	125	157	606-283-5000
IDA Corporation	26	23	701-280-1122
IFR Systems, Inc.	51	44	316-522-4981
JBRO Batteries Inc.	38	33	800-323-3779
J.E.I.	46	40	916-677-3210
JPS Communications	68	61	919-790-1011
Kantronics	123	151	913-832-6268
Kaval Electronics	64	56	905-940-1400
Kenwood Communications	71	64	310-639-4200
King Communications USA Inc.	84	77	407-291-9009
KNS Electronics Inc.	135	178	408-432-8100
Larsen Electronics	39	34	800-426-1656
Leathersmith	104	103	800-233-0440
Leavitt Communications Inc.	96	92	847-676-8282
Linktronics Systems Inc.	91	86	714-952-3683
Loral Microwave-Narda East	72-73	65	516-231-1700
Loral Microwave-Narda West	69	62	916-638-5500
Marketronics Corp	20	19	800-845-1230
Maxrad, Inc.	55	48	708-372-6800
McManus Communications	118	136	501-763-6250
Mechem Electronics	122	146	540-891-0569
Meridian Communications	15	13	818-222-5655
Micro Care Corporation	28	25	800-638-0125
Microflect	IBC	2	503-363-9267
Microwave Data Systems	75	67	716-242-9600
Microwave Filter Company	56	49	315-437-3953
Midland International LMR	65	58	800-MID-LAND
Miracom Technologies Inc.	101	98	404-410-1170
Modular Communication Systems	61	53	818-764-1333
Motorola Americas Parts Div.	14	12	800-543-9191
Motorola Test Equipment	5	6	800-505-TEST
MX-COM, Inc.	142	120	800-638-5577
Natcom Inc.	53	46	800-844-8287
Norcomm Corp	110	115	916-477-8400
Omnicron Electronics	111	116	203-928-0377
Onyx Wireless Laboratories	131	169	714-374-2828
OptaPhone Systems	113	119	707-923-4000
Otto	50	43	708-428-7171
Pacific Crest	106	107	408-653-2070
Pageco	119	140	305-776-0031
Pantech America	104	104	816-891-0700
Peiker Acustic Inc.	32	28	916-888-3771
Phillips Petroleum	125	156	918-661-5970
Pipo Communications	125	158	916-644-5444
Pirod, Inc.	111	117	219-936-4221
Polaris Industries	122	147	800-752-3571
Polyphaser Corp	83	76	800-325-7170
Primus Electronics Corp	54	47	800-435-1636
Procomm	127	162	805-497-2397
Pyramid Communications	124	155	310-430-5892
Radiomate	112	118	800-346-6442
Radio Wholesale	126	160	800-53R-ADIO
RAM Communications Consultants, Inc.	116	136	908-636-6970
Ramsey Electronics, Inc.	126	159	800-446-2295
RCW Distributing	126	161	800-726-9015
Ritron Inc.	97,99,	93,95	800-USA-1USA
Ritron Inc.	101,103	,99,102	800-USA-1USA
RMS Communications Group	118	138	800-627-2022
Rocky Mountain Comms. Inc.	134		303-526-5454
Samlex America Inc.	107	109	604-525-3836
Serviceware Corporation	96	91	613-521-7391
Sharp Communication	122	145	800-548-2484
Shure Brothers Inc.	52	45	800-25S-HURE
Sinclair Technologies Inc.	98	94	800-263-3275
SoftWright	134	176	303-344-5486
Sonic Communications Inc.	12	10	800-688-1944
Standard Communications	43,45	37,39	310-532-5300
Sti-CO Industries	74	66	716-662-2680
Supercomm	64 A-L	57	703-907-7700
Survey Technology	60	52	503-591-5986
TCS Consultants Inc.	116	135	409-588-3200
Telepath.	100	96	510-656-5600
Telepoint Inc.	94	89	310-652-3666
Telewave Inc.	85	78	415-968-4400
TESSCO	25,27		800-472-7373
Times Microwave Systems	86	79	203-949-8400
TPL Communications Inc.	80	73	213-256-3000
Transcrypt International, Ltd.	3	5	800-276-8799
Trident Micro Systems	93	88	800-798-7881
Tru-Connector Corp (Mfr)	89	82	508-532-0775
Trylon Manufacturing Co. Ltd.	113	120	519-669-5421
TX RX Systems Inc.	37	32	716-549-4700
Uniden Corp of AM-MSG Inc.	66	59	817-858-3300
Utrunking Repeaters LLC NV	123	152	619-586-6280
Valmont Industries, Inc.	57	50	402-359-2201
Vega, A Mark IV Company	1	4	818-442-0782
Vertex/Yaesu USA	81	74	310-404-2700
Vocom Products Company LLC	102	101	800-USA-MADE
Wacom Products Inc.	16	15	817-848-4435
West Coast Radio	121	144	310-268-2464
Wetec Electronics	123,129	149,165	901-286-6275
Wireless World Conference	137	179	913-967-1969
W & W Associates	47	41	800-221-0732
Xcel Controls Inc.	139	181	219-259-7804
Zetron, Inc.	59,77,	51,70,	206-820-6363
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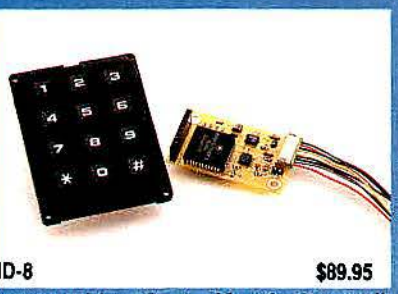

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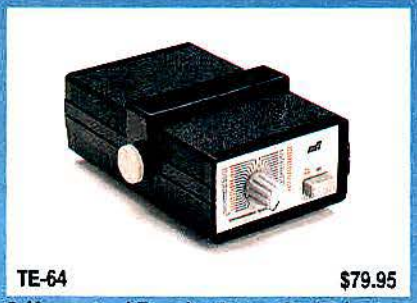

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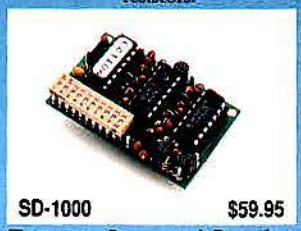

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